PREPARED FOR:

WRIA 14 PLANNING UNIT
SHELTON, WA

KENNEDY-GOLDSBOROUGH WATERSHED (WRIA 14) PHASE II - LEVEL 1 ASSESSMENT DRAFT

October 2002

Economic and Engineering Services, Inc.

Golder Associates

0231147150cv03.fh9 10/11/02

Cover:

Streams closed to further appropriation.

Red:	Year-round
Yellow:	May 1 to November 15
Orange:	May 1 to October 31
Blue:	September 16 to November 15

DRAFT REPORT

ON

KENNEDY-GOLDSBOROUGH WATERSHED (WRIA 14)

PHASE II – LEVEL 1 ASSESMENT

DATA COMPILATION AND PRELIMINARY ASSESSMENT

Prepared for:

WRIA 14 Planning Unit
Shelton, WA

Submitted by:

Golder Associates Inc.
Seattle, Washington

In association with:

Engineering & Economic Services, Inc.
Olympia, Washington

October 9, 2002 023-1147.150
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EXECUTIVE SUMMARY

Stakeholders in the Kennedy-Goldsborough Watershed have taken the initiative provided by the State of Washington under Chapter 90.82 of the Revised Code of Washington to undertake watershed planning for the watershed. The watershed comprises Water Resources Inventory Area (WRIA) 14 and is located in the southwest corner of Puget Sound.

The assessment portion of watershed planning for the portion of the Kennedy-Goldsborough Basin (WRIA 14) that drains into the south shore of Hood Canal has been transferred to WRIA 16 by an interlocal agreement. This was done to consolidate water quality efforts affecting Hood Canal.

This Level 1 Assessment provides a compilation of existing information to provide an overview of the water resources of the Kennedy-Goldsborough Basin. Based on the current understanding of the watershed and available information, the Planning Unit will decide how to proceed and allocate effort in the Level 2 Assessment.

Before embarking on Level 2 work, goals and objectives must be defined for watershed planning. With these defined, the direction of Level 2 will be more productively focused to support development of the watershed plan.

Basin Overview

The basin was delineated into four sub-basins for the purposes of this assessment. The Kennedy Sub-basin includes the drainages of Kennedy and Schneider Creeks in the south end of the basin, and includes almost the entire portion of the watershed that extends into Thurston County. This sub-basin includes the north drainage of Eld Inlet and all of Totten Inlet. The Skookum Sub-basin includes the drainage of Skookum Creek and Skookum Inlet, and includes an area of commercial development around the tribal casino. The Goldsborough Sub-basin is the largest one and includes the City of Shelton and includes approximately 60% of the basin's population. The Case Sub-basin includes Mason Lake, Sherwood Creek and Hartstene and Squaxin Islands.

The Kennedy Basin is located immediately northwest of Olympia. The City of Shelton is the only incorporated community. Major economic activities include commercial fishing and forestry. Commercial fishery has continues to grow although forestry activity has diminished significantly over the past couple of decades. The basin hosts a part of the bedroom community of Olympia. Consequently, future population growth is expected to increase relative to historical rates, and the economic and demographic makeup of the basin will correspondingly continue to change in this direction.

The population of the WRIA sub-basin was 39,410 in 2000, approximately one third in the City of Shelton City of Shelton, which is the only incorporated community in the basin. Population increased 30% basin wide over the last 10 years. The primary water resource dependent activities in the Kennedy Goldsborough Basin are:

- Population demand (drinking water)
- Shellfish harvest
- Salmon fishery

Water is also needed to support additional commercial activities.

Annual precipitation ranges from approximately 55 inches year on the coast to approximately 85 inches on the west side of the basin. The topography of the basin is relatively flat except in the southwest corner of the basin where elevations rise up to 2,400 feet above sea level. Most of the basin is underlain by unconsolidated glacial sediments (e.g., sand, gravel and till/hardpan). Basalt rocks of the Black Hills underlie the southwest quarter of the basin. The influence of the basalt rock is that it causes runoff to be higher and quicker than portions of the basin underlain by sedimentary deposits.

Hydrology

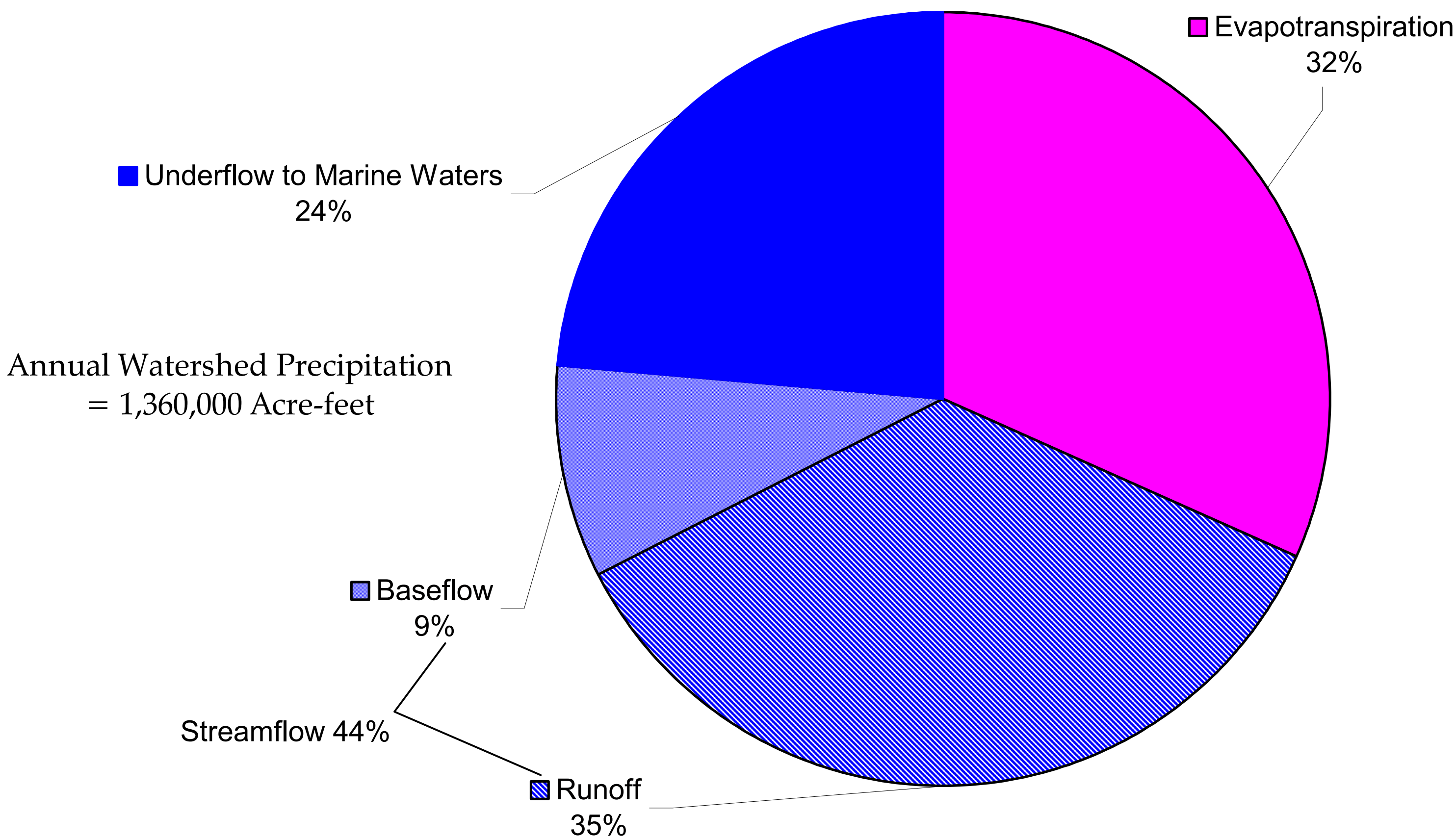
Numerous small streams that drain into the marine waters of Puget Sound that surround the basin characterize the hydrology of the basin. The larger streams consist of Kennedy (mean annual flow of ~125 cfs), Goldsborough (mean annual flow of ~65 cfs), and Skookum (mean annual flow of ~55 cfs) Creeks. Approximately 20% of streamflows are supported by a relatively constant year-round discharge of groundwater as baseflow although this varies from 6% in the Upper Kennedy catchment (which is underlain primarily by bedrock) to 24% in the Case Sub-basin (which is underlain by sediments).

Water Balance

The water balance developed in this assessment accounts for the partitioning of precipitation into evapotranspiration (~32%), stream runoff and baseflows (~44%), seasonal changes in groundwater storage, and the discharge of groundwater to marine waters as “underflow” (~24%).

Water Balance Summary

Water Balance Component	Value (AF/yr)
Precipitation	1,360,000
Evapotranspiration	430,000
Streamflow	610,000
as runoff -	490,000
as baseflow -	120,000
Underflow to Marine Waters	320,000



Instream Flows

Stream closures or flow limitations were established on approximately nine streams and lakes under the Fisheries Code between 1953 and 1975. Minimum instream flows were established on an additional 14 streams across the basin in 1984 under Ecology's Instream Resource Protection Program (WAC 173-514). Approximately 21 streams are closed to the further consumptive appropriation, which means new water rights may not be issued if they have a negative impact on the flows of those streams.

Statistical analysis of how often regulated streamflows are met was conducted on Kennedy and Goldsborough Creeks, which have at least ten years of continuous stream gaging data (1960-1971, and 1951-1971, respectively) and for which have minimum instream flow regulations are established. Regulated minimum instream flows in these creeks are not met between 50% and 60% of their period of record, respectively. The period of record for these streams was within a wet period as influenced by the Pacific Decadal Oscillation (PDO). The degree that minimum instream flows are met during a dry PDO period (e.g., 1974-1995) is not known. The influence of changing land use patterns such as urbanization on instream flows has not been assessed.

Although sufficient data for other streams is not available to conduct rigorous statistical analysis of how often the minimum instream flow regulations are met, the available data indicate that minimum instream flows are not in almost all years. This is not necessarily a reflection of over appropriation of water in the catchment of these streams, but may reflect unrealistic instream flow targets of the regulations.

Water Rights

A total of approximately 69,000 acre-feet per year (AF/yr) is estimated to be allocated in the Kennedy-Goldsborough Basin. Groundwater allocations account for slightly more than half (56%). Claims only account for 11% of the estimated allocations, which is considered relatively low when compared to other watersheds in Washington. The primary purpose of use of the allocated water is commercial/industrial (61%) and is split approximately equally between surface water and groundwater. The remaining purposes of use are split approximately equally between drinking water (including domestic and municipal uses) and agricultural irrigation (~20% each of the total allocation). Drinking water allocations are primarily groundwater while irrigation allocations are split approximately equally between surface water and groundwater. Other uses account for less than 3% of the allocated water.

Summary of Allocated Water
(AF/yr)

Purpose of Use	Groundwater	Surface Water	Total
Commercial Industrial	19,400	22,200	41,600
Drinking (domestic & municipal)	13,700	1,100	14,800
Agricultural irrigation	5,400	5,300	10,700
Other	300	1,400	1,700
Total:	**38,800**	**30,000**	**68,800**

Pending applications for new water rights represent new water supply demand for both commercial and residential growth. One of the primary purposes of undertaking watershed planning is to support the development of a policy to address these applications. There are approximately 86 pending applications for new water rights, two thirds of these for groundwater. The majority of them are for drinking water purposes (domestic uses) with the rest of them for commercial/industrial use and a few for irrigation use. The oldest application for new water rights is April 1992, and the most recent was in April 2002.

The largest volumes of water being applied for in new water rights are for multiple domestic units and include the Washington Department of Corrections in the Johns Creek drainage (600 gpm), and an application by Anderson & Sons Inc. in the Case Sub-basin on the west shore of North Bay (600 gpm). Small community systems represent the majority of other applications.

A significant number of these (i.e., ~22) are for domestic use of surface water for a single residence around Summit Lake in the Kennedy Sub-basin. Many of these were filed in the Fall of 2000. Exercise of surface water for a single domestic residence requires rigorous treatment to make it safe for drinking. Further evaluation of these applications may reveal that the applicants are willing to withdraw their applications based on the understanding of the treatment requirements to safely use the water. This would significantly reduce the backlog of pending applications in this watershed. Other than these applications for small surface water diversions, almost all applications for new water rights are for groundwater.

There are eight pending applications to change existing water rights – five for groundwater and three for surface water. Six of these are in the Goldsborough Sub-basin, and two are in the Kennedy Sub-basin. These change applications are as old as 1996.

Actual Water Use

A total of 6,600 AF/yr are estimated to be used for residential use and agricultural irrigation. Residential use represents 95% of the total use while agricultural irrigation represents only 5%. Estimates of commercial and industrial use were not included in this assessment.

Estimate of Actual Use
(AF/yr)

Purpose of Use	Total
Drinking (domestic & municipal)	6,300*
Public Water Supplies	4,900
Exempt Wells	1,400
Agricultural irrigation	310
Total:	**6,600**

* Maximum number – actual use may be as low as 5,800.

Water Quantity Summary
(AF/yr)

<table>
<tr><th>Component</th><th>Water Balance Value</th><th>Allocation</th><th>Actual Use</th></tr>
<tr><td>Precipitation</td><td>1,360,000</td><td>-</td><td>-</td></tr>
<tr><td>Evapotranspiration</td><td>430,000</td><td>-</td><td>-</td></tr>
<tr><td>Streamflow</td><td>610,000</td><td rowspan="2">30,000 (surface water)</td><td rowspan="4">6,600</td></tr>
<tr><td>as runoff -</td><td>490,000</td></tr>
<tr><td>as baseflow -</td><td>120,000</td><td rowspan="2">38,800 (groundwater)</td></tr>
<tr><td>Groundwater Flow to Marine Waters</td><td>320,000</td></tr>
</table>

Water Quality

Water quality is critical in this basin as it affects the near-shore marine environment and its effect on the shellfish industry. Excessive nutrients from agricultural activities (e.g., animal waste from feedlots), septic systems, and fertilizers cause the growth of microfauna (e.g., "red tide"). Such "blooms" result in significant commercial impacts to both tribal and private shellfish enterprises.

Natural groundwater quality is generally good, although naturally-occurring elevated concentrations of iron and manganese in deeper portions of the groundwater flow system limit the direct use of these sources for many water uses without pre-treatment.

Four marine waterbodies and 10 freshwater waterbodies are listed as having water quality impairments in WRIA 14. The most common parameter listed is fecal coliform that may be derived from agricultural practices (e.g., animal waste from feed lots), septic systems, and naturally occurring wildlife waste in sediment runoff. Other parameters associated with degraded water quality are pH and dissolved oxygen. Both of these parameters are commonly associated with high organic life (e.g., algal blooms) whose respiration causes swings in pH, and whose decomposition results in the depletion of dissolved oxygen.

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1. INTRODUCTION

Watershed planning is sponsored by the Washington Department of Ecology, who provides guidance to local stakeholders on the development of watershed management plans for water resources within a Water Resource Inventory Area (WRIA; acronyms are listed in Table 1-1). The Kennedy-Goldsborough Basin (WRIA 14) covers the southern part of the Puget Sound and is bounded to the north by the Hood Canal and the topographic divide with the Skokomish River drainage, the east by Case Inlet, the south by Eld Inlet and the Black Hills, and to the west by the topographic divide with the Lower Chehalis Basin (WRIA 22; Figure 1.1).

1.1 Purpose

The Legislature's purpose for watershed planning is "…[to determine] to provide local citizens with the maximum possible input concerning their goals and objectives for water resource management and development." The WRIA 14 Planning Unit's purpose for watershed planning is to sustainably manage water resources for humans, fish and wildlife. A required component of the Watershed Management Act (Ch. 90.82 RCW) is to conduct a quantitative analysis of the watershed including developing a water balance and assessing the current status of water allocation. Because the Planning Unit has adopted all available optional components, management of water resources as it relates to water quality, habitat, and instream flows is also addressed. The Planning Unit has great discretion with respect to the distribution of effort among these various components. The Planning Unit has made application to Ecology for additional funding available for instream flow analysis.

Thoughts on the possible final form of the watershed plan should be developed at the earliest stages of watershed planning and continue to evolve through all stages of the process. Topics of the final watershed plan and the structure of implementation will require time to develop into a form that will be: accepted by members of the Planning Unit; approved by the counties; and, be ready to be implemented. An understanding at an early stage of what form the watershed plan may assume will allow the most focused and productive allocation of effort throughout Phase II of the process.

1.2 Approach

Phase II of the watershed planning process is to develop the technical basis for preparation of a Watershed Plan in Phase III. Phase II is divided into two levels. In Level 1 (data compilation and assessment), existing data were compiled and data gaps that may impair preparation of the Watershed Plan are identified. In Level 2 (data collection and analysis), data collection may be conducted and analysis of the data made to support development of the watershed plan.

The approach to Level 1 Data Compilation and Assessment is to fulfill selected requirements of the watershed planning grant (i.e., assessment of allocation, preparation of a water balance and estimates of actual use). Fulfillment of remaining requirements will be conducted in Level 2. The approach and level of analysis will enable prioritization of the sub-basins to determine which sub-basins warrant further study and determine what additional information and analysis may be required (e.g., anticipated growth, water bodies listed under the Clean Water Act, areas of concern for listed salmonids, instream flows, etc.).

1.3 Objective

The objective of this Level 1 Technical Assessment is to compile, characterize, and provide a preliminary assessment of existing information for WRIA 14. The relevant technical data for the watershed is summarized in a context that can be used to move forward in the watershed planning process. The data presented in this Phase II, Level 1 Watershed Technical Assessment is intended for use in further analyses that address water quantity and quality issues in the Kennedy-Goldsborough Basin.

Further analyses that investigate the cause and effect relationships in the Basin will be performed for, and presented in, the Phase II, Level 2 Technical Assessment. These assessments, will in turn, be used to develop and focus a Watershed Plan that addresses critical issues with reasonable and defensible solutions that can be implemented as Phase III of the Watershed Planning Process. The Planning Unit has discussed potential Watershed Plan actions during the Phase II process that may be included as part of the Phase III Watershed Plan to help to focus this Phase II, Level 1 Assessment Report.

This Level 1 Technical Assessment is intended to partially fulfill the requirements of the Phase II, Level I Assessment of the 1998 Watershed Management Act (**RCW 90.82**) including:

- Provide an inventory of existing information relevant to watershed planning in WRIA 14;
- Organize the existing information into categories based on major technical disciplines (e.g., climate, hydrology, land use etc.);
- Present the existing information and describe the major characteristics of the watershed;
- Provide an inventory of core documents used in this assessment;
- Create a water budget for the hydrologic cycle by sub-basin for WRIA 14;
- Assess the degree of allocation and actual use of water;
- Provide a preliminary assessment of information gaps;
- Provide the foundation upon which a detailed scope of work, budget, and schedule for Level 2 Assessment of Phase II of watershed planning will be developed; and,
- Provide data to support development of a Watershed Plan under Phase III.

1.4 Authorization and Acknowledgements

This report is prepared in fulfillment of Task 150 of the April 26, 2002 scope of work entitled "Kennedy-Goldsborough Watershed, Water Resource Inventory Area 14 Watershed Planning – Phase II Level 1 Data Assessment." This scope of work was agreed to in a contract signed between Mason County and Golder Associates Inc. (Golder) on June 25, 2002.

The WRIA 14 Steering Committee contributed significantly to the preparation of this report. Jason Manassee, Mason County Department of Community Development, is the WRIA 14 Administrative Lead, on behalf of Mason County.

Chris Pitre, Senior Project Manager, Water Resources, is the project manager on behalf of Golder Associates Inc. David Banton of Golder is the Principal in Charge. Marc Horton is the project manager on behalf of Economic & Engineering Services, Inc. (EES). Philip Beetlestone, Donna DeFancesco and Michael Klisch of Golder, and Jerry Louthain of EES, participated in data collection, analysis and report preparation.

2. WATERSHED PLANNING

Watershed planning within Watershed Resource Inventory Areas (WRIAs) recognizes the large scale and complexity of water resources and the wide variety of factors that influence the amount of water available for use. Although the geographic area contained in a WRIA rarely corresponds with political/jurisdictional boundaries, water resource issues such as water supply, water quality, and habitat for fish and wildlife are closely linked together within watersheds.

From an assessment perspective, the watershed (or basin) scale is appropriate because the hydrologic processes that occur within WRIA boundaries can be approximated by a basin scale hydrologic cycle or equation. This equation can be expressed generally as "water inflow to the basin is equal to water outflow from the basin plus / minus changes in water storage within the basin". With a conceptual understanding of the hydrologic cycle within a basin, planners can gain an insight on how future actions within the watershed may impact water resources.

The 1998 Washington State legislature passed House Bill 2514, codified into Ch. 90.82 RCW, to set a framework for addressing the State's water resources issues:

> *"The legislature finds that the local development of watershed plans for managing water resources and for protecting existing water rights is vital to both state and local interests. The local development of these plans serves vital local interests by placing it in the hands of people: Who have the greatest knowledge of both the resources and the aspirations of those who live and work in the watershed; and who have the greatest stake in the proper, long-term management resources. The development of such plans serves the state's vital interests by ensuring that the state's water resources are used wisely, by protecting existing water rights, by protecting instream flows for fish and by providing for the economic well-being of the state's citizenry and communities. Therefore the legislature believes it necessary for units of local government throughout the state to engage in orderly development of these watershed plans."*

Twelve State agencies signed a Memorandum of Understanding identifying roles and responsibilities for coordination under the Watershed Management Act. This memorandum commits these agencies to work through issues in order to speak with one governmental voice when sitting at local planning unit tables. The following agencies signed this document:

- The Department of Agriculture
- The Conservation Commission
- The Department of Community, Trade and Economic Development
- The Department of Ecology
- The Department of Fish and Wildlife
- The Department of Health
- The Department of Natural Resources
- The Department of Transportation

- The Interagency Committee for Outdoor Recreation
- The Puget Sound Water Quality Action Team
- The Salmon Recovery Office, within the Governor's Office
- The State Parks and Recreation Commission

The purpose of the 1998 Watershed Management Act (WMA) is to provide a framework for local government, interest groups and citizens to collaboratively identify and solve water related issues in each of the 62 Water Resource Inventory Areas in Washington.

The WMA does not require watershed planning but instead enables a group of initiating agencies to:

- Select a lead agency;
- Apply for grant funding;
- Define the scope of the planning; and,
- Convene a local group called a planning unit for the purpose of conducting watershed planning.

The initiating agencies include all the counties within the WRIA, the largest municipality and water purveyor within the WRIA. Indian tribes with reservation lands within the watershed must be invited to participate as an initiating government; although their participation is optimal, participation is not required for watershed planning to proceed.

Upon successful completion of Phase I, Ecology may grant up to $450,000 per WRIA to fund watershed planning: $200,000 for Phase II (Assessment), and $250,000 for Phase III (Watershed plan development). Under the law, the Planning Unit has considerable flexibility to determine the planning process, focus on areas or elements of particular importance to local citizens, assess water resources and needs, and recommend management strategies.

The WMA identifies four topics that can be addressed within the watershed assessment plan. Water quantity must be addressed if grant funds are accepted. Water quality, habitat and instream flows may be addressed but are optional. The Kennedy-Goldsborough Planning Unit has elected to address the optional component of water quality. The law specifies certain types of information that must be gathered and a range of water resource management strategies that need to be addressed.

Ecology may also make available supplemental funding of up to $100,000 for expanded studies on of each of the following areas: instream flow, water quality and storage. Future applications by the Planning Unit may be made for funding to support instream flow, water quality and storage considerations.

The law also includes constraints on the activities of planning units. For example, the Planning Unit does not have the authority to change existing laws, alter water rights or treaty rights, or require any party to take an action unless that party agrees. A watershed plan may, however, contain recommendations for changing state or local laws.

Three phases of watershed planning are identified in the WMA:

- Phase I - Organization
- Phase II - Assessment
    - ⇒ Level 1 Assessment: A compilation and review of existing data (within time and budget limitations) relevant to defined objectives. If the Planning Unit decides that the existing data are sufficient to support the management requirements of all or some of the issues, the Planning Unit may choose to skip Level 2 and move on to Level 3 for these issues.
    - ⇒ Level 2 Assessment: Collection of new data within the time frame of the planning process to fill data gaps and to support decision needs.
    - ⇒ Level 3 Assessment: Long term monitoring of selected parameters following completion of the initial watershed plan to improve management strategies.
- Phase III - Planning

The WMA requires, at a minimum, that a watershed plan be approved by a consensus of the Planning Unit members representing government units, and a majority vote of the non-governmental members of the Planning Unit. Following approval by the Planning Unit, the WMA calls for a joint session of the legislative session bodies of all counties in the watershed to consider the plan. The counties can recommend changes to the plan but the Planning Unit must agree to make the changes for them to be effective. Once the plan has been approved by the county's legislative body and the Planning Unit, the county and state agencies are required to implement the plan.

The Planning Unit shall not add an element to its watershed plan that creates an obligation unless each of the governments to be obligated has at least one representative on the planning unit and the respective members appointed to represent those governments agree to add the element that creates the obligation. Obligations agreed to by agencies shall be adopted by rule as soon as possible (Ch. 90.82.130 (3) RCW).

2.1 WRIA 14 Planning Unit

The Initiating Governments started the Kennedy-Goldsborough Watershed Planning effort in 2001. These include all counties with land within the WRIA (Mason, Grays Harbor, and Thurston Counties), the largest municipality (City of Shelton), the largest non-municipal purveyor (Mason County PUD #1), and tribes with reservation lands within the WRIA (Squaxin Island Tribe). The initiating agencies and their representatives are listed below.

Initiating Government Members
Mason County
Thurston County
Grays Harbor County
Squaxin Island Tribe
City of Shelton
Department of Ecology
PUD # 1 of Mason County
Non-Governmental Members
Mason County Citizen
Thurston County Citizen
Shelton Citizen
Business
Construction/Development
Environmental
Fisheries Industry
Salmon Recovery
Recreational
Timber
Agriculture
Ports
Water Purveyors
Residential Property Owners
Ex-Officio Members
Mason Conservation District
Thurston Conservation District
WSU Cooperative Extension

Stakeholders in the watershed were invited to participate as members of the Planning Unit. The Planning Unit meets on the fourth Thursday of each month. The Planning Unit also established a Technical Committee that meets on the second Thursday of each month. The role of the Technical Committee is to address and discuss individual issues in greater depth. All resolutions of the Technical Committee are subject to approval by the Planning Unit. Participation at all meetings of the Planning Unit and Technical Committee are open to the public, and is encouraged.

2.2 WRIA 14 Background Issues

As the population in both rural and urban areas has grown, the demand on water resources has also grown. Because water resources are limited watershed planning is needed to ensure that increased out of stream demands are satisfied without unacceptable impacts on the natural environment. Some of the important issues to the planning unit and in the watershed planning process include:

2.2.1 Water Quantity

Water resources in the Kennedy-Goldsborough watershed is limited to that provided by precipitation. There is no contribution from upstream watersheds. There is negligible snow pack to provide inter-seasonal storage. The primary waterbody accessed for development is groundwater, although surface water is also used. Precipitation provides water to the terrestrial environment as runoff in streams and recharge to groundwater. Some of the groundwater discharges back to streams in the form of baseflow, while the remainder of groundwater discharges to the Hood Canal and Puget Sound. Redirecting the flow of water within the watershed through groundwater withdrawals or surface water diversions may result in impacts to the natural system. Such impacts may result in the direct reduction of stream flows, reduction of baseflows, and associated effects such as higher surface water temperatures and reduced fishery habitat.

Development of land in the watershed also affects the flow of water through the watershed. Deforestation, impervious surfaces and constructed of stormwater conveyance facilities route rain water more quickly to streams and out of the watershed, rather than allowing it to recharge to groundwater and subsequent slow release to streams as baseflow.

2.2.2 Water Allocation

Many of the streams in the watershed have been closed to further consumptive appropriation thereby inhibiting the allocation of additional water for consumptive uses. There are approximately 99 water right applications pending of which approximately 86 are for new water rights, and 13 are for changes to existing water rights. One of the primary purposes of conducting watershed planning is to provide a framework within which to facilitate processing of these and future applications. Future water resource development is anticipated to occur primarily in groundwater. Development of groundwater may affect instream flows through hydraulic continuity. Therefore, the assessment of the hydraulic continuity between surface water and groundwater is an important relationship to characterize.

2.2.3 Exempt Wells

Exempt wells are the use of groundwater that does not require a permit and generally serve one to six residences. Individually, exempt wells may have insignificant impacts on the water resources of the watershed, however when taken collectively, they may form a significant portion of the total water resource development. Where land use development associated with exempt wells occurs in conjunction with septic systems, a significant portion of the extracted water may be returned to the aquifer system through recharge from septic systems (less the amount used for landscape irrigation and lost to evapotranspiration).

2.2.4 Instream Flows

Instream flows were established in the Kennedy-Goldsborough watershed under Ecology's Instream Resources Protection Program (IRPP) in 1983. Previous to 1983 several streams were closed to further consumptive uses under the Fisheries Code (RCW 75.20). Under the IRPP, which was promulgated into rule (Ch. 173-514 WAC), additional streams were closed to further consumptive use either for portions of the year. These stream closures, combined with a poor documentation of hydraulic continuity of groundwater and surface water, have inhibited the processing of applications for new water rights.

2.2.5 Water Quality

The WRIA 14 Planning Unit has assumed the optional component of water quality in the watershed planning process. A number of surface water bodies in the watershed have been listed under section 303(d) of the Clean Water Act and will require the establishment of Total Maximum Daily Loads (TMDLs) and Clean-up Action Plans. Maintaining a high level of water quality is important to the watershed for recreational and commercial (e.g., shellfish) use, for the maintenance of salmonid habitat, and for the long-term protection of groundwater quality.

2.2.6 Fisheries Habitat

Water quantity and quality are important to fish habitat. The decline in salmon abundance and recent listing of Puget Sound chinook and Hood Canal summer chum under the Endangered Species Act reflect a coast-wide decline in salmonid habitat quality. Local efforts are being undertaken to address habitat concerns include the efforts by citizen committees formed under the Salmon Recovery Act (Ch. 75.46 RCW) to identify and prioritize salmon restoration and preservation projects.

The shellfish industry is very important in this basin for tribal and commercial production as well as recreational use. Water quality in nearshore marine waters reached a low point in the past few decades, but has recently been improving. Maintaining viable and healthy aquatic habitat will reflect a successful resolution of many of the other water resource management issues in the watershed.

3. THE HYDROLOGIC CYCLE

The hydrologic cycle forms the technical basis for watershed planning. At a global scale, the hydrologic cycle describes the circulation of water between the oceans, atmosphere and land. At the watershed scale, the hydrologic cycle focuses on the land-based hydrologic system that is bounded by surface water divides such as hill ranges, and sinks such as marine bodies. For WRIA 14, the watershed area is comprised of five sub-basins: Case, Goldsborough, Kennedy, Skookum and South Shore (Hood Canal). Surface water drains from these sub-basins via creeks and steams as well as coastal tributaries to the Hood Canal and Puget Sound. Groundwater in the watershed discharges water to these streams and directly to the surrounding marine waters of the Puget Sound.

A watershed should be viewed as a combination of both the surface drainage area and the groundwater in the subsurface soils and rocks that underlie the watershed (Figure 3.1). A good understanding of the hydrologic cycle at the watershed scale involves an inventory of the water inputs, outputs and storage within the watershed. Knowledge of the dynamic processes of a watershed hydrologic cycle provides an understanding of what effects various resource management approaches will have on the natural system.

It is also useful to also represent the hydrologic cycle as a systems diagram. Figure 3.2 illustrates the systems approach to the basin scale hydrologic cycle and differentiates between those terms that involve rates of movement (hexagonal boxes) and those that involve storage (rectangular boxes).

The hydrologic cycle, illustrated in Figures 3.1 and 3.2, is a network of inflows and outflows that may be expressed as a water balance or water budget by equating the primary variables (input, output and change in storage):

$$\text{Input} = \text{Output} +/- \text{Change In Storage}$$

This equation is a conservative statement that assures that all the water within the watershed is accounted for and that water cannot be lost or gained. The main input to the hydrologic system is precipitation primarily in the form of rainfall, and to a lesser degree snowmelt. The primary natural outputs are evapotranspiration to the atmosphere, and streamflow (or runoff) and groundwater discharge to marine waters. Evapotranspiration is the combination of evaporation from open bodies of water, evaporation from soil surfaces and transpiration from the soil by plants. Outflow from a watershed also occurs as a result of human consumption and redirection of flows. The primary change in storage is the interseasonal change in groundwater storage mainly reflected by fluctuations in groundwater levels.

Movement of water within a watershed occurs naturally through a number of processes. Overland flow delivers precipitation to stream channels. Infiltration results in movement of water at the land surface downward into the subsurface. Groundwater flow results in movement of water within the subsurface. Baseflow delivers groundwater to stream channels. Streamflow or surface water flow results in movement of water within stream channels. The natures of the land surface and subsurface determine infiltration and groundwater flow rates. Infiltration rates and groundwater flow rates, in turn, influence the timing and spatial distribution of surface water flows.

Groundwater flows and surface water flows are linked by the relationships between infiltration, groundwater recharge, baseflow and streamflow generation.

Movement and outflow/inflow of water within a watershed is also impacted by a number of human factors including groundwater pumping, extraction of surface water, stormwater generation and discharge, wastewater generation and discharge, and agricultural and land use practices.

The hydrologic cycle at a watershed scale is most commonly analyzed on an annual basis over the water year, defined as October 1 through September 30 (i.e. the beginning of autumn through to the end of summer). Successive years are compared so that changes in the water budget (and its components) can be assessed. The primary variables are affected by seasonal, interannual, interdecadal and decadal variability (e.g.: dry versus wet years; El Nino / El Nina; and, Pacific Decadal Oscillations, respectively).

4. KENNEDY-GOLDSBOROUGH WATERSHED DESCRIPTION

The Water Resources Act of 1971 defined 62 Watershed Resource Inventory Areas (WRIAs) in Washington State for the purposes of managing water resources including the administration of water rights. The Kennedy-Goldsborough Watershed (WRIA 14) is located in northwestern Washington State and is bounded by the maritime waters of the Puget Sound, and Case Inlet (Figure 1.3). In addition to mainland areas, the watershed encompasses the islands or Hartstene, Stretch and Squaxin islands. The WRIA covers an area of 381 sq. miles (244,208 acres) and is subdivided by three counties (Kitsap, King, Mason and Pierce; Figure 1.2). The greatest percent of the WRIA is in Mason County followed by Thurston, and Grays Harbor Counties.

County	Acres	Square Miles	Percent
Grays Harbor County	31	0.05	< 0.1%
Mason County	166,588	260	84%
Thurston County	30,356	47	15%
Total WRIA 14	196,975	307	100%

Note: These figures are for land area only and do not include marine waters.

The majority of the watershed's population is located in unincorporated areas. The major incorporated population center is the City of Shelton. Squaxin Island forms the Squaxin Island Tribe reservation.

4.1 Physiography

The WRIA's physiographic and topographic features are similar to much of the area surrounding the Puget Sound and were formed by the deposition of glacial drift. The most predominant deposit on the peninsula is glacial till, with a lesser amount of exposed silts and clays were also deposited. The topography is moderately subdued and consists of flat-topped rolling hills and undulating uplands. Elevations range from 100 to 400 feet MSL, with the exception of Black Hills, in the southeastern portion of the watershed, that rise to an elevation of approximately 2,400 feet MSL.

4.2 Sub-Basins

The Kennedy-Goldsborough watershed is subdivided into five sub-basins based on surface water and topographic divides. The sub-basins for the purposes of this assessment are Case, Goldsborough, Kennedy, Skookum and South Shore (Figure 1.3, Table 4-1). The South Shore Sub-basin, even though a part of WRIA 14, is not addressed in this assessment, but is included in the WRIA 16 Level 1 Assessment.

The analysis in this Level 1 Assessment is conducted at the resolution of these sub-basins. However, conditions may vary internally within a sub-basin and general findings arrived at in this Level 1 Assessment about each sub-basin may not be locally accurate to certain areas within a sub-basin. Potential inconsistencies may be addressed in more detailed planning that will result from the overall watershed planning process. A brief description of each of the sub-basins is discussed in the following sections.

4.2.1 Case Sub-Basin

The Case Sub-basin is the second largest of the WRIA sub-basins covering 119 mi^2. However 27 percent of the acreage is marine water bodies. This sub-basin includes Hartstene and Squaxin Islands. Drainage to marine waters is through small short creeks to Pickering and Peale Passages, Case Inlet and North Bay. The major surface water drainage is Sherwood Creek that drains Mason Lake.

4.2.2 Goldsborough Sub-Basin

The Goldsborough Sub-basin is centrally located in the watershed and is the largest of the basins encompassing 160 mi^2. The watershed's sole incorporated area, the City of Shelton, is within this sub-basin. This sub-basin encompasses all of Oakland Bay and Hammersley Inlet in which significant commercial shellfish harvest is conducted. Goldsborough Creek is the primary creek draining 55 mi^2. Other major creeks include: Mill Creek that drains from Isabella Lake to Hammersley Inlet; Cranberry Creek, that drains Cranberry Lake, and Deer Creek both of which drain to the head of Oakland Bay; and, Johns Creek that drains to Oakland Bay. The basin is underlain predominantly by unconsolidated sediments with basalt of the Black Hills extending into the southwestern corner of the sub-basin.

4.2.3 Skookum Sub-Basin

The Skookum Sub-basin is the smallest at 37 mi^2. It encompasses all of the land draining to Skookum Inlet, and a portion of land draining the north shore of Totten Inlet. Skookum Creek is the major creek in this basin. The Squaxin Island Tribe's commercial development is located in the drainage of Skookum Creek and includes a casino. The drainage covers approximately equal amounts of land underlain by glacial sedimentary deposits and basalt bedrock of the Black Hills.

4.2.4 Kennedy Sub-Basin

The Kennedy Sub-basin covers the southern edge of the Kennedy Basin and encompasses most of the drainage to Totten Inlet and the north shore of the Eld Inlet drainage. The major freshwater drainages are Kennedy and Schneider Creeks both of which discharge to the head of Totten Inlet. Perry Creek drains to the head of Eld Inlet. Approximately 75% of the Kennedy Sub-basin is underlain by basalt bedrock of the Black Hills. This high percentage of bedrock causes runoff of precipitation to be relatively quick, which results in correspondingly lower summer streamflows than would occur in a sub-basin underlain by sedimentary deposits.

4.3 Climate

The Kennedy Goldsborough watershed has a temperate maritime climate and is typified by short, cool, dry summers and prolonged mild, wet winters. Annual precipitation varies considerably over the region ranging from an average of less than 55 inches along the east side of the basin, increasing to approximately 85 inches along the western edge of the basin (Figure 4.1). The wettest and driest months are January and July, respectively (Figure 4.2, Table 4-2). Temperatures range from an average low of 38 °F (3.3 °C) in January to an average high of 64.5 °F (18.1 °C) in August (Table 4-3). Generally, temperatures infrequently drop below freezing and snowfall accumulation is minimal. Precipitation supplies groundwater recharge and stream runoff throughout the watershed. All water flowing out of the watershed eventually discharges to the surrounding marine waters of Puget Sound and Hood Canal.

In assessing watersheds, quantifying the amount and variability of precipitation is of utmost importance because it supplies inputs for groundwater recharge and stream flows. Precipitation varies both temporally and spatially. This variability is complicated by multiple factors such as seasonal variation, dry versus wet years, and large scale influences (e.g., hemispherical) of the El Nino / La Nina, and Pacific Decadal Oscillations. Even in a year with average annual precipitation, the distribution of precipitation between the months may not be average. In addition regional and local topographic features and water bodies can affect precipitation.

Although precipitation falls as rain or snow, there is negligible snow influence in the hydrology of this watershed. Because snowfall in the study area is minimal and snowpack is not a factor in the storage of water, the volume of water realized from snow and snowpack, that could contribute to streamflows and aquifer recharge will be considered negligible. Therefore snowfall and snowpack are not being addressed in this report.

Because marine water bodies and topographic high points bound WRIA 14 and there are no water bodies flowing into the basin (i.e., there are no upstream watersheds), precipitation is the sole natural input of fresh water source for recharge and runoff.

There are two National Oceanic and Atmospheric Administration (NOAA) Cooperative meteorological stations in WRIA 14 that can aid in understanding precipitation variations across the region (Figure 4.1). These stations have periods of record greater than 50 years. To augment the data from the NOAA stations outputs from the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) were used to represent precipitation data for the WRIA.

The PRISM model uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters (Daly and others, 1994). The PRISM model was developed by meteorologists specifically to address climate. PRISM is well suited to reflect the effects of terrain on climate. This study uses PRISM to estimate mean annual, mean monthly and event-based precipitation, temperature, and other variables. The model grid resolution is 4-km square. The outputs used in this study are re-sampled to 2-km resolution using mathematical filtering procedures (Daly and others, 1994).

The PRISM precipitation data are considered to be of high quality due to the vast amount of data used in the analysis and the high degree of peer review that the model has received since it was published.

In order to confirm if PRISM precipitation data adequately approximates the actual precipitation within the WRIA 14, a comparison was made between average annual

PRISM precipitation and average annual precipitation for the two representative WRIA 14 NOAA climate station data (Figure 4.1). Both stations agreed to within 2.2 percent of the PRISM data.

4.4 Geology

The Tertiary volcanic rocks consist of basalt flows and breccias of the Crescent Formation and are exposed only in the Black Hills province in the southwest corner of WRIA 14. The remainder of WRIA 14 is covered by Pleistocene glacial till and outwash from the Vashon Glaciation, with comparatively minor amounts of alluvial deposits present along the major rivers within the WRIA (Figure 4.3).

The recent geologic history of the Kennedy-Goldsborough watershed area consists predominantly of Quaternary Pleistocene and Holocene unconsolidated glacial and interglacial sediments deposited over the last two million years. The unconsolidated sediments were deposited over Tertiary bedrock materials consisting primarily of basalt. These sediments were deposited by at least six distinct glacial and interglacial periods, the most recent of which was the Vashon Glaciation.

The repeated glacial and interglacial episodes (of which the Vashon Glaciation was the most recent) resulted in the deposition of up to 3,000 feet of unconsolidated sediments in the Puget Sound Lowland (Molenaar and Noble, 1970; Figure 4.3). In WRIA 14, the thickness of unconsolidated deposits ranges from absent in the southwest corner of the watershed to nearly 1,800 feet in the east (Jones, 1996). Glacial depositional sequences generally consist of advance outwash deposits, overlain by till and recessional outwash deposits.

The coarser phases of the glacial till and outwash form the primary aquifers from which groundwater is drawn in WRIA 14. Finer grained outwash sediments and poorly sorted till typically have less water resource development potential. In WRIA 14, the coarse-grained advance outwash is present in the south along sides of the Kamilche Valley. The recessional outwash located north and northwest of Shelton can yield small to moderate quantities of water (50-250 gpm) when present in sufficient thickness below the water table (Molenaar and Noble, 1970). Coarse sediments consisting of cobbles, gravels, sands are present along western border of WRIA 14 between Goldsborough Creek and W. State Highway 108. These coarse sediments have high permeabilities and likely allow recharge of lower aquifers (Molenaar and Noble, 1970).

4.5 Population

Current and future populations and their water use habits, provide a means of estimating how much water is currently being used and may be used in the future. Population data were obtained from the US Census Bureau for the 1990 and 2000 census distributed by census block. Census blocks are areas defined by the Census Bureau bounded on all sides by visible features such as streets, roads, streams, and railroad tracks, and by invisible boundaries such as city, town, township, and county limits, and short imaginary extensions of streets and roads.

Where census blocks straddle sub-basin boundaries, the population of the census block was distributed between the sub-basins proportional to the area of the census block in each sub-basin. This assumes the population to be evenly distributed within the block. In actuality, this may not be the case. However, the error is considered acceptable for the purposes of this study given the size of the population being examined.

4.5.1 Population Distribution

The distribution of population is characterized in this report for the purposes of estimating current and future water use (Figure 4.4). Population data were obtained from the US Census Bureau for the 1990 and 2000 census and was distributed by census block. Census blocks are defined by the Census Bureau and are usually bounded on all sides by visible features such as streets, roads, streams, and railroad tracks, and by invisible boundaries such as city, town, township, and county limits, and short imaginary extensions of streets and roads.

The population data was descretized by subbasin. Where census blocks straddle sub-basin boundaries, the population of the census block was distributed between the sub-basins proportional to the area of the census block in each sub-basin. This assumes the population to be evenly distributed within the block. In actuality, this may not be the case. However, the error is considered acceptable for the purposes of this study given the size of the population being examined.

The population of the WRIA sub-basin was 39,410 in 2000. Population distribution in the WRIA can be differentiated as incorporated or unincorporated areas. The majority of the population resides in rural, unincorporated areas. Twenty two percent of the population lives within the incorporated areas the City of Shelton. No other incorporated areas are present in the WRIA. Other densely populated areas include the areas immediately adjacent to and north of the City of Shelton, and in the Spencer and Phillips Lakes area.

Location	Population (2000)	Percent
WRIA 14 Total	39,410	100%
Grays Harbor County	0	0%
Mason County	33,478	85%
Thurston County	5,932	15%
City of Shelton*	8,470	22%

Note: * Populations obtained from State of Washington, OFM forecasting, as of April 1, 2001.

4.5.2 Recent Population Growth and Current Densities

Current population was evaluated from 2000 US census bureau data and compared to 1990 census data (Table 4-5). The watershed's population increased by 9,007 people, or approximately 30%, from 1990 to 2000. The largest population growth rate occurred in the Skookum sub-basin at 43 percent over ten years (Figure 4.5). However the greatest increase in population numbers was in the Goldsborough sub-basin, with an increase of 5,597 people. The highest population density also occurs in the Goldsborough sub-basin, which encompasses the City of Shelton.

4.5.3 Projected Population Growth

Projected growth in the watershed was assumed to continue at the current growth rates observed from 1990 to 2000. Projected yearly growth rates are presented in Table 4-6. If growth from the period 1990-2000 continues at the same rate until 2010, the 2010 population of the basin will be 49,386 people.

5. HYDROLOGIC CHARACTERIZATION

5.1 Basin Hydrology Overview

There are 139 identified streams providing over 240 linear miles of creeks, tributaries, and independent streams in the basin. All the streams are typical, low land types, with their headwaters originating from natural springs, and surface water drainages, swampy beaver ponds or small lakes in foothills. The principal drainages are Cranberry, Goldsborough, Kennedy, Mill, Sherwood, and Skookum Creeks, with many smaller streams discharging into Case Inlet and Hood Canal.

Because snow and snow pack are not a major factor in the watershed streamflows reflect seasonal variation in precipitation. In addition to directly contributing to streamflow maintenance, those sources also contribute to storage in lakes and groundwater aquifers that serve as natural reservoirs, helping to moderate extreme high and low flows.

5.2 Surface Water

Streamflow represents the final phase of water in the hydrologic cycle, barring consumptive losses, as it moves from the watershed. It is the easiest variable to measure and therefore often used for regulatory controls. In this section methods of analyzing streamflow will be presented along with existing data. The goal of this section is to build a basis for understanding how streamflow is affected by natural variability.

5.2.1 Background Issues

Streamflow is one of the most commonly measured hydrologic variables. However, a proper characterization and interpretation of streamflow data requires acknowledgement of a number of factors, including:

- **Natural variability:** Natural variability of streamflow occurs both spatially and temporally and is affected by differences in:
  - Soils
  - Geology
  - Precipitation
  - Climate
- **Hydraulic continuity:** Hydraulic continuity of groundwater and surface water can play an important role in flow levels, particularly during dryer periods. How quickly and where groundwater and surface water interact is crucial to understanding streamflow.
- **Accuracy and precision of measurements:** Stream gaging sites are generally chosen specifically to provide precise and accurate results. However, measurement errors are inherently introduced when collecting streamflow data. Inaccuracies can also be introduced through, changing technology, geomorphic variability, human error, and machine error. These errors typically range from 5% to 20%, depending on site conditions. Additionally, flow out of a catchment through groundwater (underflow) is not measured by stream gaging.

- **Timing and location of water use:** The timing and location of water use can influence streamflow and baseflow levels through almost every aspect of the hydrologic cycle. The affects of these withdrawals vary with the magnitude of use.
- **Land cover and land use:** Land use and land cover changes can affect interception and evapotranspiration timing and rates, as well as how much and how quickly water infiltrates or runs-off to streams.

Ultimately, each of these physical variables must be balanced against regulatory issues and multiple streamflow needs including in-stream uses for fish habitat, environmental considerations and aesthetics, and out-of-stream uses for irrigation and domestic uses. Streamflow is also the most commonly regulated hydrologic variables, and is usually the ultimate basis for legal allocation of water.

5.2.2 Available Data

A review of available flow data from USGS gaging stations within the Kennedy Watershed was conducted. A total of 22 flow gaging stations within the basin were documented as having historical flow data although there are no currently active stations. Of these, nine were operated by the USGS and have varying lengths of continuous stream gaging data (Table 5-1; Figure 5-1). Only two stations (Goldsborough and Kennedy Creeks) have greater than a ten-year period of continuous records. Intermittent flow measurements were made by Ecology at the other during the preparation of the minimum instream flow rule in the early 1980s (Ch. 173-514 WAC).

5.2.3 Presentation of Data

Hydrologic data is complex, highly variable, and cannot be represented by a single presentation or analysis of data. The data is presented here using several methods to represent each aspect of a system, and to characterize the hydrologic regime.

5.2.3.1 Average Annual Flows

Annual averages are commonly used to evaluate inter-year trends. Mean annual flows for Kennedy and Goldsborough Creeks over the period of record are presented in Table 5-1. Mean annual flows for each year are displayed in Figure 5-2 and 5-3. Precipitation at Shelton for 1964 was recorded at 33 inches and was considered anomalous, and is therefore not plotted.

These plots can provide an indication of inter-annual flow variations, and the correlation with precipitation. The mean annual flow in 1952 for Goldsborough Creek appears to be anomalous and should be further assessed before being used in an additional analysis. The deviation of precipitation from a direct correlation to precipitation represents a number of influences including changes in interannual storage (e.g., a year with average precipitation may have less than average streamflow if it follows a dry year), differences in annual temperature (a warm year would result in additional loss to evapotranspiration), and other influences (Figures 5-2a and 5-3a). There are no perceptible distinct trends in the available dataset.

5.2.3.2 Average Monthly Flows

Monthly averages can be used to evaluate inter-year trends on a monthly basis as well as intra-year trends. Monthly averages aid in visualizing the relative contribution of monthly flows to total annual flows as well as how these monthly flows relate to each other. In addition, monthly averages can indicate how monthly values vary with annual increases or declines in precipitation and flow. Average monthly precipitation is also plotted. The distribution of streamflow and precipitation within an actual year may vary significantly from average.

In general, streamflow tracks precipitation closely with a lag time of approximately one month (Table 5-2; Figure 5-4 and 5-5). The resolution of the analysis and plots does not allow rigorous comparison. However, the lag time appears to be smaller for the Kennedy drainage, which is consistent with the Kennedy drainage being comprised of a higher percentage of basalt bedrock that in turn causes quicker runoff.

5.2.3.3 Average Daily Flows

A hydrograph presents streamflow in a basic form - streamflow (or stage) versus time. A hydrograph can provide very detailed information on a watershed when completed on a daily or hourly time step. Actual hydrographs, as opposed to aggregates, are used to describe the elements, or phases of the hydrologic cycle and provide the best insights into the drivers that cause each element's response. Unfortunately, because of the complexity of hydrograph response, it is difficult to automate or numerically analyze individual hydrographs. Therefore, analysis is often best completed through observation.

The basic elements of a hydrograph are shown on Figure 5-6 include the following:

- Baseflow (late fall to winter);
- Rising limb (spring);
- Peak flow (spring);
- Peak flow recession (summer); and
- Baseflow recession (summer/fall).

The baseflow recession and baseflow periods represent an important period in the Kennedy-Goldsborough watershed due to in-stream needs. A description of each element and associated drivers are discussed in the paragraphs below.

The rising limb is the period of time when run-off from both small (rain) and large (snowmelt) events begins to reach the stream. The shape and rate of streamflow increase on the rising limb is affected by the size and shape of the watershed, as well as snow storage, temperature, land cover, and infiltration capacity.

Peak streamflow represents the largest rate of streamflow during a year. Annual averages of streamflow are often greatly influenced by peak flow, because peak flows often represent the greatest volume of water, being ten or 100 times greater than low flow conditions. Peak flows benefit the natural fish habitat by flushing channels, restoring gravel beds that are used for spawning by salmonids, and shaping stream channels.

Peak flow recession follows the peak flow period. The recession limb is the period when rain begins to decrease. This portion of the hydrograph is supported by the lag time that some precipitation runoff takes as it drains from headwater areas.

Baseflow recession represents a transition period when streamflows become increasingly supported by groundwater baseflow. This slope of this recession is much less than during peak flow, but is greater than during true baseflow. During this period, some water in the stream is still directly derived from shallow interflow (runoff of precipitation that is the shallow subsurface).

Baseflow is defined as the "component of streamflow derived from groundwater inflow or discharge" (Sinclair and others, 1999). Baseflow represents streamflow, derived from precipitation that infiltrates into the soil and eventually moves through the soil and discharges to the stream channel. It is often the primary source of streamflow during dry periods when there is little or no surface water run-off. The rate and volume of baseflow can also be influenced by surface water leakage from storage sites, well operations, and groundwater withdrawals. During baseflow periods it is easier to see anthropogenic (human-related) effects because few other hydrologic inputs are active during these dry periods.

Daily hydrographs for the two stations with greater than ten years of continuous USGS data in are presented in Figures 5-7 and 5.8. Each figure displays two hydrographs, the average daily flow and the daily flow for the 1969 hydrologic year. (The hydrograph from 1969 is shown because that year had an average annual precipitation.)

The rising limb extends from October to December. Peak flows are during winter months from December to May. Recession from the peak extends from May, approximately, to the end of June. Baseflow recession is visible from the decline in the slope that occurs in July and early August. Baseflow is reached by mid-August and extends through September.

5.2.3.4 Exceedance Curves

Exceedance curves are used to understand how often, or how probable, it is that that a certain flow will be exceeded in a specified time frame. Exceedance probabilities are also called recurrence intervals, or, more generally, frequency analysis. Frequency analysis techniques were primarily developed by civil engineers, who needed to determine design criteria for hydrologic structures, particularly during hydrologic extremes (e.g. floods and droughts). The source of data for these types of analysis is purely historical. The analysis is dependant on the length of the period of record and the range of flows seen within that period. Therefore, the validity of results generally increases with the length of the record.

Frequency analysis was performed on USGS gaging stations with a period of record of a minimum of 10 years, which are:

- USGS no. 12076500 Goldsborough Creek near Shelton
- USGS no. 12078400 Kennedy Creek near Kamilche

Exceedance curves for 10%, 50%, and 90% probabilities were computed for 7-day average flows using the entire period of record available at each gage (Figures 5-9 and 5-10). A frequency probability plot is not a hydrograph and it is highly unlikely that flow in any year would be represented by an exceedance curve. For example, the occurrence of a 90% exceedance flow of 200 cfs from January 1-7 does not imply that the following 7-day period will be at the 90% exceedance flow.

5.3 Groundwater

Groundwater is anticipated to provide for future water supply development. Direct surface water diversions are less likely to occur in the future because of the direct impacts that it has on fishery habitat, and the rigorous treatment standards required if it is used for potable uses.

5.3.1 Background

The groundwater system underlying the watershed is part of the Puget-Willamette Trough regional aquifer system. The Puget-Willamette Trough aquifer system underlies an elongated basin that extends southward from near the Canadian border in Washington to central Oregon. The basin consists of three areas: the Puget Sound lowland in northern Washington; a central area that extends southward from the Puget Sound lowland to northern Oregon and includes part of the Columbia River Valley; and, the Willamette River Valley that extends southward from the Columbia River to central Oregon. The Kennedy-Goldsborough watershed is situated in the South Puget Sound lowland.

5.3.2 Available Data

Unconsolidated-deposit aquifers make up the principal aquifers of the system in the South Puget Sound lowland. The thickness of the glacial deposits underlying the watershed ranges from a thin veneer covering the basalt outcroppings around the Black Hills, to over 1,600 feet under Hartstene Island (Jones, 1996) (Figure 4-3).

The sands and gravels that were deposited during the last period of glaciation compose the most productive aquifers in the lowland and generally form the upper 200 to 300 feet of the unconsolidated deposits. Some public-supply and most private wells in the watershed have been completed in the in shallow sand and gravel of glacial origin, yield from 1,000 to 1,500 gallons per minute. At depth, sand and gravel deposits typically are discontinuous lenses (Jones, 1996). Although they are usually much less permeable because of compaction, these lenses can yield large volumes of water to wells. Well yields vary greatly and commonly exceed 2,000 gallons per minute. Deeper aquifers are not as commonly developed due to water quality problems such as higher manganese and iron concentrations (Molenaar and Noble, 1970).

The major source of recharge is precipitation. Water enters the groundwater system through deep percolation of precipitation and the downward and lateral seepage form surface ponds, lake and rivers. The extent to which precipitation will infiltrate the surface and recharge the groundwater system varies spatially and is dependant on both the character of surface soils and geology. In areas such as the Black Hills, which are underlain by impermeable formations, much of the precipitation that falls on the land becomes surface runoff. By contrast in the areas underlain by more permeable glacial drift a larger portion of precipitation percolates to the groundwater system.

Although numerous wells withdraw water from the unconsolidated-deposit aquifers in the Puget Sound lowland, only a small percentage of the total discharge from the aquifers is withdrawn by wells. Most groundwater discharges to streams, lakes, and surrounding marine waters. Only minor amounts of water are discharged to springs and seeps. The general flow of ground water is towards discharge points and roughly follows the land surface slope.

Due to the relatively high permeability of the glacial drift and the relatively low permeability of the geology area around the Black Hills, groundwater recharge will be a major component of the physical hydrologic water balance and a large water source to meet the needs of the watershed's stakeholders.

Groundwater quality in WRIA 14 is variable due to the number of geologic settings within the WRIA. In the vicinity of Kamilche Valley, calcium, magnesium and bicarbonate comprise more than 50% of the constituents in groundwater and concentrations are consistent between shallow and deep aquifers (Taylor and others, 1999). High lead concentrations have been reported in wells on Squaxin Indian Reservation land along the ridge between Totten and Little Skookum Inlets (Taylor and others, 1999). These lead concentrations are more likely to be a result of plumbing rather than naturally occurring. Iron is also present in groundwater pumped from aquifers interbedded with organic material, such as peat, which is common in glacially deposited sediments (Molenaar and Noble, 1970). Another groundwater quality issue is potential contamination from septic and wastewater systems. Contamination of shallow groundwater is most likely to occur where there is concentrated development.

6. WATER BALANCE

The hydrologic cycle forms the technical basis for watershed planning. The traditional method for expressing the hydrologic cycle is through a water balance of the primary elements of the hydrologic cycle. The conventional physical water balance for watershed assessments considers the proportioning of water among the components of precipitation, evapotranspiration, runoff and storage (represented by groundwater in this basin – there is no significant snow pack storage influences). It is this approach that is presented in this chapter.

Other types of water balances may be considered. Within a quantified limit of water availability, water may be apportioned among various uses including consumptive and non-consumptive out of stream uses, and environmental and instream flow uses. A water balance of out of stream uses can also be prepared in which the timing of diversions/withdrawals and returns, consumptive uses, and wastewater streams are analyzed. Another type of water balance is an accounting of the various components of withdrawn water such as septic system returns, wastewater plant discharges, and irrigated water (evapotranspiration and return flows).

An understanding of the hydrologic cycle at the watershed scale involves an inventory of the water inputs, outputs and storage within the watershed. A schematic of the hydrologic cycle is shown in Figure 3-1 and expanded upon in Figure 3.2.

The hydrologic cycle's distribution of components and timing of water movement can be altered by human impacts. Water storage and transport affect the timing of surface water movement through the system in both the stream flow, evaporative and groundwater phases. Changes in land use and land cover alter infiltration, evaporation, transpiration and run-off rates.

A water balance's units are, by convention, inches and acre-feet. Values expressed in inches are typically used when apportioning fractions of precipitation to components of the water balance. Values expressed in acre-feet are typically used to compare the relative magnitude of the components of the water balance between sub-basins. This is an important distinction as an inch of water in a large sub-basin represents more water than an inch of water in a small sub-basin.

6.1 Background Issues

The Kennedy-Goldsborough watershed is a not one single hydraulically closed system, but the composite of multiple catchments draining into Puget Sound. This study analyzes the watershed as four discrete sub-basins; the water balance for the Hood Canal South Shore sub-basin is addresses in the WRIA 16 level 1 Assessment. All water in the system originates from precipitation that falls in the watershed as rain or snow. Therefore, the Kennedy-Goldsborough watershed lends itself well to a simple water balance using only precipitation inputs. The sub-basins are delineated based on surface topographic divides. Although groundwater flow patterns are expected to approximate these delineations, they may differ from surface water drainage patterns.

The surface geology of a watershed directly impacts the groundwater and surface water components of the water balance. The surface geology of the watershed is 11 percent basalt and 89 percent unconsolidated sediments. The spatial distribution these geologic formations and their relative permeability directly affects the relative volumes of each of the water balance components within each sub-basin.

Surface water flow/stream flow in the watershed has historically been monitored by the USGS. However, very little data was collected and then only for limited or discrete periods of time. The best records are for Kennedy and Goldsborough Creeks, both of which have at least ten years of continuous data. Skookum Creek has approximately seven years of continuous data. All other creeks have less data or none.

Conceptually, there are two distinct flow regimes in the basin: sub-basins underlain by bedrock resulting in quick runoff and little groundwater storage; and, sub-basins underlain by unconsolidated sediments (e.g., sand and gravel) resulting in less runoff and higher groundwater storage. As a result of the watershed's geology, climate and the inadequacy of surface water data, the water balance of WRIA 14 presents some unique challenges and the traditional method of calculating a water balance will require modification. To model the watershed effectively, a subbasin with a strong bedrock influence and one with a strong sedimentary influence are used to develop a water balance of each sub-basin of the watershed.

The relative magnitudes of each hydrologic parameter are aggregated at a sub-basin spatial scale, and a monthly time scale. This format can be easily implemented in a spreadsheet, but lacks the fine scale necessary for site-specific studies. Therefore, it provides a basis for management strategies that will affect hydrologic features at a gross scale. Most hydrologic parameters in a water balance are directly measured (precipitation, streamflow, etc.), while others, such as groundwater, are calculated as a "residual" in the water balance equation.

6.2 Water Balance Methodology

The analytical water balance data and results are contained in Appendix A. Because groundwater is anticipated to be a significant component in developing a watershed plan for this basin, the following water balance equation is used:

Precipitation = Evapotranspiration + Runoff + Baseflow + Change in storage + Groundwater underflow

In some basins, change in storage may be in the form of snow pack or change in groundwater storage. Snow pack is not a significant variable in the hydrologic cycle of the Kennedy-Goldsborough watershed and is therefore not considered in the water balance analysis. Changes in storage in WRIA 14 will be primarily reflected in fluctuations of groundwater levels.

As a result of limited streamflow gage data and the two distinct geologies within the watershed (i.e., sedimentary and bedrock), the water balance methodology used in this assessment will based on the water balances of two catchments, Upper Goldsborough and Upper Kennedy catchments and extrapolated to other areas. These two catchments are unique in the watershed because both have long-term historical stream gaging data and are predominantly underlain by unconsolidated sediments and basalt, respectively.

A description of the water balance calculations is provided in the following sections. Data and results are presented in Appendix A.

6.2.1 Water Balance Calculations for Kennedy and Goldsborough Creeks

A mix of empirical data (real data) and analytical (estimates based on an understanding of physical processes) was used to derive the water balances. The empirical data used were average precipiation (from PRISM) and stream flow gaging records. Evapotranspiration (ET) was calculated and the remaining components were derived from these three components (precipitation, streamflow and ET). Stream flow data from the 1969 hydrologic year (October 1, 1968-September 31, 1969) are used because it represents an average precipitation year.

Precipitation: Precipitaiton is taken directly from PRISM data which is modeled average precipitation available at a monthly resolution.

Separation of Stream flow into Baseflow and Runoff: Total streamflow is taken from USGS stream gaging data. The minimum monthly streamflow occurs in August or September when there is minimal rain. Therefore this minimum monthly streamflow was taken to represent the groundwater contribution to streamflow as baseflow. Because groundwater gradients at a sub-basin scale vary only slightly throughout the year, baseflow is assumed to be constant year round. In actuality, baseflows have some seasonal variation that parallels gross streamflows and so this assumption may result in an underestimation of baseflow contribution during higher streamflow periods. The amount of streamflow above baseflow is runoff.

Evapotranspiration: The difference between total annual precipitation and streamflow is greater than can be accounted for by normal rates of ET and could not be reasonably estimated through a straight difference of these components. Therefore ET was calculated for each catchment analyzed.

Groundwater Residual: When the components of precipitation and streamflow plus ET are accounted for on a monthly basis, there is a significant "residual." That is, the balance of these three components does not equal zero. This residual is assigned to groundwater components which are assumed to represent groundwater flow out of the basin, and interseasonal changes in groundwater storage. This groundwater residual is separated out into groundwater underflow, and changes in groundwater storage, as described in the following two paragraphs.

Groundwater Underflow: The difference between streamflow and precipitation on an annual scale that is not accounted for by ET is assumed to represent groundwater flow out of the catchment. This component is called "underflow." As for baseflow, groundwater gradients at a sub-basin scale vary only slightly throughout the year, and underflow is assumed to be constant year round. Therefore the annual difference of precipitation less streamflow and ET is distributed evenly across all of the months. As characterized, this underflow does not discharge to streams but discharges to marine waters of Puget Sound.

Groundwater storage: Because the groundwater residual is a seasonally varying number, and groundwater underflow is constant year round, the variation in the groundwater residual is assumed to represent seasonal changes in groundwater storage. During the rainy season, groundwater storage increases through natural recharge. Groundwater storage is depleted during the drier months as a result of evapotranspiration by uptake through plant roots. This change in seasonal groundwater storage has a net annual balance of zero.

To apply the concepts decribed above, the water balances for the catchments of Upper Kennedy and Upper Goldsborough catchments are arrived at through the following steps:

- Calculate the monthly precipitation in the catchment using PRISM data;
- Calculate monthly evapotranspiration using the Blaney-Criddle method and PRISM average monthly temperature;
- Calculate the monthly stream flow for each catchment using USGS gaging data and develop runoff relationships based on the percentage of the basin underlain by basalt;
- Assume that year round baseflow is constant and equal to the minimum monthly streamflow; and,
- Determine monthly groundwater residual by subtracting streamflow and actual evapotranspiration from annual precipitation.

6.2.2 Extrapolation of Water Balance Calculations to All Sub-basins

The same approach is used to develop water balances for the other catchments in the basin, and for each sub-basin. However, because streamflow data are not available for these other catchments, stream flow is estimated by extrapolating from the Kennedy and Goldsborough catchments.

For each of the watershed's four sub-basins the water balance components of precipitation and evapotranspiration are available or can be calculated. Therefore, the only unknowns in the water balance are surface water flow and ground water residual. Using the relations developed from the catchments, surface water runoff and groundwater residual can be determined and in turn underflow and baseflow are calculated. The methodology for extrapolating the catchments' water balances to each sub-basin is summarized below:

- Calculate monthly volume of available water (**precipitation** – estimated actual **evapotranspiration**) for each sub-basin;
- Calculate **annual runoff** for each sub-basin using the relationship of annual runoff to available water and the percentage of basalt covering the sub-basin (Figure A-3):
- Distribute annual runoff between the months to create an annual hydrograph, using monthly percentages of annual runoff determined based on the relationship of **monthly runoff** for the two catchments and the percent of basalt covering each catchment;
- Subtract actual evapotranspiration and runoff from precipitation, for each month, to estimate **monthly groundwater residual**;

- Calculate annual **baseflow** using the relationship of annual baseflow to groundwater residual (Figure A-4), and distribute it across the months evenly; and,
- Estimate **monthly underflow**, by the differnce of groundwater residual and underflow.

6.3 Water Balance Components

This section describes the approach to completing the water balance. Each water balance component was calculated, either directly or indirectly, using existing data sources. These components are then summed on a monthly basis within each sub-basin to estimate a yearly water balance.

The following components are incorporated for each sub-basin water balance on both a monthly and annual resolution.

1. Average monthly precipitation (PRISM data).
2. Average monthly temperature (PRISM data).
3. Run-off.
4. Soil Moisture: calculated on a monthly basis using the methodology established by Thornthwaite and Mather.
5. Potential Evapotranspiration: calculated using the Blaney-Criddle method and adjusted to account for soil moisture to develop an estimate of actual evapotranspiration.
6. A net water balance: the residual calculated on a monthly basis in which groundwater recharge is estimated as the remainder from precipitation after accounting for run-off, and evapotranspiration.

The general approach for the annual water balance on a sub-basin basis is:

$$P = RO + AET + GWR \qquad [1]$$

Where:

P = Precipitation, an externally modeled component, based on measured data.

RO = Runoff, a modeled component, a percent of precipitation based on USGS studies.

AET = Actual evapotranspiration, on a monthly time step.

GWR = Net groundwater residual calculated through the water balance.

The methods used to estimate each component in the water balance are described below.

6.3.1 Precipitation

Monthly precipitation values, used in this assessment, were aggregated by sub-basin using data modeled by Climate Source, Inc. (PRISM data) using weather data from stations with long periods of record and interpolated accounting for topographic influences (see section 4.3 for a more detailed discussion of precipitation). The difference between the PRISM data and a climate station in Shelton, Washington is approximately 2% (Figure 4-1).

6.3.2 Evapotranspiration and Soil Moisture

Evapotranspiration (ET) is calculated for each sub-basin in WRIA 14, using the Blaney-Criddle method (Dunne and Leopold, 1978) and calculated on a monthly resolution. The Blaney-Criddle calculates potential evapotranspiration (PET) using longitude and latitude, average air temperature, the monthly fraction of annual day light hours and an empirical crop coefficient. The monthly crop coefficient for evergreens (k=1.2) is used because the majority of the watershed is vegetated with conifers.

Actual Evapotranspiration (AET) was calculated from the PET by accounting for changes in soil moisture using a method established by Thornthwaite and Mather. As soil moisture changed PET was adjusted to account for water availability using the following criteria and resulting relationships:

If precipitation is equal to or greater than potential evapotranspiration, then:

$$AET = PET$$

If precipitation is less than potential evapotranspiration, then:

$$AET = PET \quad (\text{if } SM/SMC >= 0.75)$$

Or:

$$AET = PET*1.3*(SM/SMC) \qquad (\text{if } SM/SMC >= 0.75)$$

Where:

AET = Actual evapotranspiration (inches/yr)

PET = Potential evapotranspiration (inches/yr) calculated by the Blaney-Criddle Method

SM = Soil Moisture content from the pervious month (inches)

SMC = soil moisture holding capacity (inches)

Evapotranspiration for all 4 sub-basins was calculated using a soil moisture holding capacity of six inches and represents a loam soil with a rooting depth in the order of three feet. However, the soil moisture holding capacity in general varies with soil type. For the purposes of this water balance, SMC was taken to be a constant and therefore did not vary with soil type or by sub-basin.

6.3.3 Runoff and Streamflow

The definition of runoff is quite variable and is dependent upon the time scale that is used in defining the portion of rainfall that ends up in streams. Land use changes may significantly alter the runoff patterns both through impervious surfaces and through removal of forest duff. Forest duff, comprised of organic litter, contributes a significant water holding capacity. Simple replacement of forest duff with grass may result in significantly higher runoff, and less recharge to the groundwater system.

Shallow perched subsurface flow (interflow), which contributes to stream flows within the time scale of hours to days after a precipitation event is also commonly included as runoff. Baseflow hydrograph regression analysis may consider a time scale of several days to weeks and involve precipitation that has recharged to the shallow portion of the groundwater system and that subsequently discharges to streams.

Groundwater discharge to streams several days to weeks after a precipitation event is generally considered to be baseflow, as defined through hydrograph regression analysis, even though it ultimately results in runoff. The path taken by precipitation recharged to groundwater resulting in baseflow may flow through shallow and deep portions of the aquifer system. Precipitation that is recharged to groundwater in the watershed discharges to both streams and the saline waters of Puget Sound and Hood Canal.

For the purposes of this water balance assessment runoff will be assume to be the result of short term effects and the baseflow of the streams will be assumed to be ground water component. Runoff will be estimated using relationships developed from the two USGS gaged catchments within the watershed.

6.3.4 Groundwater Recharge

For the purposes of this Level 1 Assessment, groundwater recharge is assumed to be precipitation minus evapotranspiration and runoff (i.e., recharge = precipitation - evaporation - runoff). The reliability of the groundwater recharge estimates is dependent upon the methods of analysis and accuracy applied to the estimates of evapotranspiration and runoff. The Blaney-Criddle method of estimating evapotranspiration is well established and accepted. The amount of precipitation remaining after evapotranspiration consists of runoff and groundwater recharge. Therefore, artifacts of analysis from assumptions affecting runoff will inversely affect estimates of groundwater recharge.

6.4 Discussion

Annual estimates for each of the water balance components are presented in Table 6-1 and displayed in Figures 6-2 and 6-3. Water balance components on a monthly resolution for each sub-basin are presented in Appendix A. The distribution the normalized (normalized to a unit area) value of the various water components versus precipitation is listed in Table 6-1. Figure 6-4 shows each water balance component as a percentage of precipitation. Evapotranspiration remains relatively constant, regardless of the amount of precipitation. As precipitation increases, so do runoff and groundwater recharge.

Conceptually, evapotranspiration is relatively insensitive to precipitation above a minimum amount of precipitation if the main process of evapotranspiration is through vegetation. Potential evapotranspiration (PET), and actual evapotranspiration as it relates to PET, is a function of temperature alone. As precipitation increases, plants will transpire a relatively constant amount of water, and therefore evapotranspiration as a proportion of precipitation decreases with increased precipitation.

At sufficiently low levels of precipitation, all water that does not go to evapotranspiration is recharged to groundwater with no runoff. As precipitation increases, runoff forms. At sufficiently high levels of precipitation, the maximum ability of the soil to receive water (field capacity) is reached and recharge becomes constant. This results in a decreasing amount of recharge to groundwater as a proportion of water remaining after evapotranspiration, even as precipitation continues to increase.

Water recharged to the shallow groundwater system provides baseflow to streams, replenishment of soil moisture and recharge to deeper aquifers. Water recharged to the deeper groundwater system may discharge directly to Puget Sound and may provide some baseflow to streams.

Uncertainties and assumptions described in this section may introduce error into the monthly timing and volume of estimated hydrologic losses. Possible sources of inaccuracies include:

- Estimating runoff as a percentage of available water. Runoff is dependent on soil type, soil moisture, subsurface geology, and land use / cover patterns.
- Estimating baseflow as a percentage of groundwater residual on an annual basis.
- Using a single value for soil moisture content. Soil moisture content is variable between soil types.
- Using a single crop coefficient of evergreens to represent all vegetation types.

Overall, for the purposes of this Level 1, Phase II watershed planning effort, the water balance estimates will provide a comparative understanding of the distribution of water between precipitation, evapotranspiration, streamflows, and groundwater.

7. ALLOCATED WATER RIGHTS

This chapter provides an assessment of the degree of allocation of water in the Kennedy-Goldsborough Basin estimated from claims and administratively issued water rights. Ecology maintains a database to track and store water rights information, called the Water Rights Application Tracking System (WRATS) database. An abbreviated version of the WRATS database, called "**W**RATS-**O**n-a-**B**un," or WOB, that is current as of August 2001 will be used for the assessment of allocation in the Kennedy-Goldsborough Basin. However, because WRATS is the more common reference to the WOB database, all references in this report to WRATS is actually to the WOB database. Current information on applications for new water rights and change applications was also obtained from Ecology to assess the current degree of water rights activity in the basin. Finally, instream flow regulations are reviewed.

7.1 Water Rights in Washington

Administrative water rights issued by Ecology have existed in Washington State since 1917 for surface water and 1945 for groundwater. These take the form of permits and certificates and are collectively referred to as administratively issued water rights. Legal water use since these dates requires application to, and approval from, Ecology. Water rights are valid only as long as they are used, and except under specific conditions, cease to exist if they are not used for a continuous period of five years (i.e., they are relinquished). A description of claims is presented below because of the uncertainty associated with the status of claims in the assessment of allocation.

Water use before 1917 (for surface water) or 1945 (for groundwater) is "grandfathered" in and establishes a water right, subject to conditions (e.g., the water must be applied to beneficial use, must not have been relinquished, etc.). Such rights are referred to as claims, and must have been registered with Ecology. Since the establishment of the surface and groundwater codes, there have been four claim registration periods. Claims for water use may have been registered multiple times resulting in duplicate, triplicate, or possibly quadruplicate records in Ecology's database for what is intended to be a single water right claim. Claims do not necessarily represent a valid water right, and Ecology does not have the authority to determine their validity.

Approximately 177,000 claims were filed statewide in the initial opening to the water right claims registry (July 1, 1969 through June 30, 1974) in response to Ch. 90.14.041 RCW. A list of the information that the claimant had to provide was specified in Ch. 90.14.041 RCW. In 1973, Ch. 90.14.041 RCW was amended to allow a less extensive list of information – a "short form" filing. The short form only requires inclusion of sufficient data to identify the claimant, source of water, purpose of use and legal description of the land upon which the water is used and is of limited evidentiary value in adjudications. With the amendment to RCW 90.14.051 in 1973, there are long forms (exclusively used prior to 1973, and selectively used after 1973) and short forms.

The intent was that short forms were supposed to be used only by those who were withdrawing water pursuant to Ch. 90.44.050 RCW (exempt wells), but that is not what happened in practice. The language in Ch. 90.14.051 RCW is as follows: "Except, however, that any claim for diversion or withdrawal of surface or ground water for those uses described in the exemption from the permit requirements of Ch. 90.44.050 RCW may be filed on a short form to be provided by the department." This language is confusing because there is no exemption for the diversion of surface water under Ch. 90.44.050 RCW.

The second opening was from July 1, 1979 through December 31, 1979, and was created by Ch. 90.14.043 RCW.

That section of the code was amended in 1985 to allow a third opening was July 1, 1985 through September 1, 1985. In those cases the claimant first had to petition the Pollution Control Hearings Board for a certificate and make a showing to the PCHB regarding their water use. A certification was issued by the Pollution Control Hearings Board if, upon petition to the board, it was shown to the satisfaction of the board that:

(a) Waters of the state have been applied to beneficial use continuously (with no period of nonuse exceeding five consecutive years) in the case of surface water beginning not later than June 7, 1917, and in the case of ground water beginning not later than June 7, 1945; or,

(b) Waters of the state have been applied to beneficial use continuously (with no period of nonuse exceeding five consecutive years) from the date of entry of a court decree confirming a water right and any failure to register a claim resulted from a reasonable misinterpretation of the requirements as they related to such court decreed rights.

If the claimant received a certificate from the Board, then Ecology accepted the filing of the claim and entered it into the claims registry.

The fourth opening from September 1, 1997 through June 30, 1998 was created by a new section of the code, Ch. 90.14.068 RCW. These claims are commonly entered into the WRATS database without designation as to whether they are long or short form claims.

Each of the openings came with limitations and differences from the other claim openings and most of that information can only be gleamed by reading the various laws that created/limited the openings. For example, filings in the September 1, 1997 through June 30, 1998, opening have a water right priority date of as of the date the statement of claim is filed with Ecology – even though to be a valid claim the water use needed to start prior to 1917 for surface water and 1945 for ground water.

An adjudication must be conducted to determine the validity of claims, and to resolve conflicts between water rights holders. An adjudication is a court process that may be initiated by petition by a person claiming a right to water, by Ecology, or by planning units. There have been no adjudications in the Skokomish Basin.

Water rights may be established for instream flow values under the Water Resources Act of 1971 (Ch. 173-500 WAC). Regulated instream flow quantity is a water right with a corresponding priority date and period of use. The purpose of establishing such flows is typically for the maintenance and/or protection of aquatic biota/fish, although other values may also be considered, such as water quality and recreational uses. Water may also be reserved or set aside for future use. Ecology must initiate a review of such regulations whenever new information, changing conditions, or statutory modifications make it necessary.

No other forms of water rights are addressed in this chapter including, but not limited to, tribal rights. A groundwater right for the withdrawal of up to 5,000 gallons per day of groundwater for prescribed uses may be established without application to Ecology, and are referred to as "exempt wells." Exempt well use is addressed in the chapter assessing actual use.

7.2 Assessment of Allocation

This section describes water rights allocated by the Washington Department of Ecology (Ecology) in the Kennedy-Goldsborough Basin and by sub-basin. The characterization of water rights was based on:

- Source type (groundwater or surface water);
- Document type (certificate, permit, claim, etc.);
- Purpose of use (irrigation, domestic, municipal, etc.); and,
- Subbasin.

The WRATS database was initially queried to exclude those documents listed in the database as relinquished, rejected, cancelled, or otherwise listed as not being in good standing. The extracted data were placed in a new database for further analysis. A total of approximately 4,500 records were extracted from the WRATS database for WRIA 14. Of these, approximately 400 records occur in the area draining to the south shore of Hood Canal and are not considered further as these were included in the assessment of allocations for WRIA 16. The documents in the WRATS database for WRIA 14 are summarized in the following table:

Document Type	Number of Documents	
	Groundwater	Surface Water
Applications	59	29
Certificates	351	631
Change Applications	8	4
Claim/	1	1
Claim/L	1,529	286
Claim/S	1,254	269
Permits	13	62
Subtotal	**3,215**	**1,282**
Total	**4,497**	

Information on Certificates, permits, and claims from WOB database (August 2001). Information on applications and changes from Ecology (July 2002).

7.2.1 Characterization by Purpose of Use

For each subbasin, the database was queried to extract the distribution of documents by purpose of use for both groundwater and surface water. The order of extraction was as follows:

- All documents including the "MU" (municipal) purpose of use;
- Remaining documents including the "IR" (irrigation) purpose of use;
- Remaining documents including the "D*" (domestic) purpose of use;
- Remaining documents including the "CI" (commercial-industrial) purpose of use;
- Remaining documents with non-consumptive or infrequently used purposes of use (power, fish propagation, and fire); and,
- All other documents including all other purposes of use (mining, recreation, stock, etc).

After each query, the records are removed from the database before applying the next query. This characterization is based solely on the number of records. The results of the analysis by purpose of use are summarized on Table 6-1. The approach for an assessment of allocation based on the volume of water is presented in the next section.

Non-consumptive (e.g., fish hatchery or hydropower production) or infrequently used (e.g., fire suppression) water rights contributed less than one percent of all documents. Because annual quantities are usually not listed in the WRATS database for these types of water rights, they are not further characterized with respect to associated annual quantities following initial extraction from the database. The surface water diversions for non-consumptive or infrequently used purposes of use are summarized as follows:

- One certificate for 1 cubic foot per second (cfs) for power generation;
- Two certificates totaling 3.4 cfs for fire protection;
- Seven certificates for fish propagation totaling 26.957 cfs; and
- One permit for 0.05 cfs for fish propagation.

Groundwater withdrawals for non-consumptive or infrequently used purposes of use are summarized as follows:

- One certificate for 120 gallons per minute (gpm) for fire protection.

7.2.2 Assignment of Annual Withdrawals or Diversions

Water rights are assigned with a variety of properties among which are an instantaneous withdrawal/diversion rate (Qi; in gallons per minute [gpm] for groundwater and cubic feet per second [cfs] for surface water), and an annual withdrawal/diversion rate (Qa; acre feet per year for both surface and groundwater). (Groundwater is typically described with the term "withdrawal" while surface water is generally described with the term "diversion." The terms withdrawal and diversion may be used interchangeably in this report.) Assessment of allocation on a watershed scale is appropriately considered by examination of the annual permitted quantities, which may then be seasonally distributed.

The annual quantity the WRATS database includes instantaneous withdrawal rates (Qi) for almost all administratively issued rights (permits and certificates). However, annual withdrawal rates (Qa) are missing for many administratively issued rights and almost all claims. Surface water permits and certificates generally have a higher percentage of records with missing Qa than groundwater permits and certificates. For records that do not include Qa, the Qa is assigned to allow an assessment of allocation. The method of estimating assigned Qa is described below.

7.2.2.1 Certificates and Permits

Within each group of purpose of use, the ratio of Qi/Qa of water rights was calculated for both surface water and groundwater for rights for which both parameters are defined (Table 6-2). The duty for irrigation rights was also calculated (Table 6-2). The mean and median Qi/Qa was calculated for each purpose of use. For certificates and permits for non-irrigation use without Qa, the Qa was estimated by multiplying the Qi by the median Qi/Qa ratio. The median Qi/Qa is considered most representative, as outliers in the Qi/Qa ratio do not skew it.

For irrigation rights without Qa, the Qa was calculated by multiplying the irrigated acreage for each right by the median duty for either surface water or groundwater (Table 6-2).

7.2.2.2 Assignment of Qa to Claims

Long and short form claims generally do not contain complete information on Qa, Qi, or irrigated acres, and therefore require an assignment of Qa. New claims filed during the last claim registration period (September 1, 1997 through June 30, 1998) have Qa and Qi information.

Short form claims are generally equivalent to exempt well as defined in Ch. 90.44.050 RCW, such as for domestic water use and limited irrigation (i.e. less than 0.5 acre). Short form claims were assigned a Qa of 0.5 AF/yr, regardless of purpose of use, consistent with domestic, stock, and limited irrigation use. Long form claims have a purpose of use of general domestic were also assigned a Qa of 0.5 AF/yr.

For long form claims with irrigated acreage information, the duty calculated from water rights was applied.

Long form claims for irrigation use without a defined number of irrigated acres were assigned a Qa based on the median number of irrigated acres for groundwater or surface water rights, and a corresponding duty calculated from water rights.

For the remaining long form claims, the purpose of use includes stock, or no purpose of use is listed. A Qa of 2 AF/yr was assigned to all of these remaining long form claims.

7.3 Allocation by Subbasin

The WRATS database lists the location of water rights and claims by Township, Range, and Section (TRS). Sections and associated water rights and claims were assigned to subbasins based on the subbasin in which the centroid of the section was located. If the centroid of a particular section fell within the defined subbasin boundary, all water rights in that section were included in that subbasin regardless of whether portions of that section were located in other subbasins. It is therefore possible that some water rights that were located within a particular subbasin were assigned into a different subbasin as the centroid of that section was in the different subbasin. The artifacts of this division are shown on Figure 7-1.

A number of water rights and claims have a place of use that covers multiple sections. For these documents, the Qa was allocated between sections by dividing the total Qa by the number of sections.

7.4 Results

A total of 68,842 AF/yr is allocated in WRIA 14. Groundwater accounts for 38,780 AF/yr, or 56 percent of the total allocation. The remaining 30,063 AF/yr (44 percent) is surface water. Groundwater certificates and permits account for 34,528 AF/yr, or 89 percent of the allocated groundwater. Claims account for the remaining 11 percent, or 4,252 AF/yr, of allocated groundwater (Table 7-3). Surface water certificates and permits account for 28,665 AF/yr, or 95 percent of the allocated surface water. Claims make up the remaining 5 percent (1,398 AF/yr) or allocated surface water.

The largest allocation of water in WRIA 14 is for commercial-industrial use. A total of 41,651 AF/yr is allocated for commercial-industrial use, accounting for 61 percent of the total allocated water. 19,415 AF/yr of groundwater is allocated for commercial-industrial use. 22,236 AF/yr of surface water is allocated for commercial-industrial use. Irrigation and domestic allocations of water are similar (Table 7-4). Irrigation allocations are divided almost equally between groundwater and surface water, while most of the domestic allocations are from groundwater. Municipal use accounts for a total of 4,538 AF/yr, with 4,034 AF/yr of the total allocation from groundwater (Table 6-4). All municipal water rights in WRIA 14 are held by the City of Shelton. Other uses of water account for 1,688 AF/yr, or about two percent of the total allocated water in the basin.

The Goldsborough subbasin has the largest allocation of water in WRIA 14 of 56,338 AF/yr, or about 82 percent of the total allocated water. Much of the water withdrawals and diversions are in the vicinity of the City of Shelton. The Skookum subbasin has the lowest allocation of water (2,446 AF/yr), four percent of the allocated water in the basin. The distribution of surface water diversions and groundwater withdrawals are shown on Figures 7-2 and 7-3, respectively. There are current applications for 5,794 gpm from groundwater and 2.69 cfs for surface water in the basin (Table 7-5). There are six change applications for groundwater, and three change applications for surface water. The Goldsborough Sub-basin has the greatest amount of current water rights activity (Figure 7-4).

7.5 Administrative Status of Instream Flows

Minimum Instream flows for the Kennedy – Goldsborough watershed are contained in Chapter 173-514 WAC (Ecology, 1988). The Instream Resources Protection Program (IRPP) - Kennedy-Goldsborough Water Resource Inventory Area (WRIA) 14 is authorized under the Water Resources Act of 1971 (RCW 90.54.020(3)(a)) and supported by Chapters 90.22 and 75.20 RCW. Under the Minimum Water Flows and Levels Act (RCW 90.22.010, 1969) the state is authorized to establish minimum water flows. Under

RCW 75.20.050, 1949 the Department of Ecology may deny or otherwise limit water rights permits. The historical and current administrative status, as well as the technical basis of current minimum instream flows in the Kennedy-Goldsborough watershed is summarized here.

7.5.1 Closures under the Fisheries Code

Under Chapter 75.20 RCW, eight stream closures in the Kennedy-Goldsborough watershed were established as water right actions of Ecology or it's predecessor agencies. A lake level limitation on Summit Lake was also established by court decree. RCW 75.20.050 provides that Ecology may deny or otherwise limit water right permits if, in the opinion of the director of Game or director of Fisheries, such permit might adversely affect the ability of the stream to support game or food fish populations (Ecology, 1983). Existing surface water source limitations are presented in the following list.

- Goldsborough Creek, a tributary to Oakland Bay is closed as of 4/14/1954.
- Gosnell Creek, a tributary to Isabella Lake, has a source limitation of low flow as of 12/4/1961 (10 cfs at a point 600 ft E – 200 ft N of W1/4 corner S. 10, T. 19 N., R. 4 WWM).
- Jarrell Creek, a tributary to Jarrell Cove, has a source limitation of low flow as of 7/7/1959 (0.30 cfs or less).
- Johns Creek, a tributary to Oakland Bay, has a source limitation of low flow as of 7/7/1959 (4 cfs at a point 650 ft N - 650 ft E of center of Sec. 1, T. 20 N, R. 4 WWM).
- Kennedy Creek, a tributary to Totten Inlet, as a source limitation of low flow as of 10/15/1953 (3 cfs).
- Schneider Creek, a tributary to Totten Inlet is closed as of 5/4/1953.
- Skookum Creek, a tributary to Skookum Inlet is closed as of 6/25/1975.
- Summit Lake, a tributary to Kennedy Creek, has a source limitation of lake level as of 11/29/1954.
- Unnamed Stream in Sec. 34, T. 20 N., R. 3 E.W.M., a tributary of Mill Creek, has a low flow source limitation as of 2/11/1953 (2 cfs at a point 100 ft E and 800 ft N of SW corner of Sec. 34, T. 20 N., R. 3 WWM).

Closures and low flow limitations also apply to tributaries of these streams.

7.5.2 Current Administrative Status

Instream flow levels, described in Chapter 173-514 WAC (Ecology, 1988), were developed using current and historical studies completed on the hydrology and instream resources of the basin. Studies identified in the IRPP include the following.

- Miscellaneous flow measurement collected by Ecology during 1980-83 in order to improve stream flow correlations between gaged and ungaged streams.
- Continuous stream flow measurements collected by the USGS between 1942-71 on 7 streams.
- The Goldsborough Creek inflow study completed by Ecology (WDOE Technical Report for WRIA 14) to determine inflows to lower Goldsborough Creek.

- Flow recommendations developed by Washington State Department of Game (WDG) and Washington State Department of Fisheries (WDF) using the "U.S.G.S" instream flow technique. A method using standard regression equations developed from data collected on Western Washington streams to derive preferred rearing and spawning flows. Recommendations are shown in Table 2 of the IRPP (Ecology, 1983).
- Flow recommendations of the Squaxin Island Indian Nation based on tribal biologists knowledge of typical spawning and rearing flows. Recommendations are shown in Table 2 of the IRPP (Ecology, 1983).
- Instream Flow Incremental Method (IFIM) study results completed for Goldsborough Creek by Ecology in cooperation with Simpson Timber Company, the Squaxin Tribe, WDF, WDG, and the U.S. Fish and Wildlife Service. The IFIM method was completed using discharge, stage, velocity and depth measurement from 10 cross sections within two study sites on the creek. Data for chinook, coho, and chum salmon as well as steelhead trout, developed by Ecology, WDF and WDG, were input to an IFG-4 model. This model provided weighted usable area versus discharge tables that were used as the basis for determining proposed instream flows. More detail, and plots of these curves, can be found in the IRPP (Ecology, 1983).

Instream flows and closures were adopted from the original IRPP (Ecology, 1983) and enhanced in Chapter 173-514 WAC (Ecology, 1988; Table 7-6, Figure 7.5). Additionally, lakes in the WRIA are to be retained substantially at their natural levels.

Minimum instream flow levels are defined for 10 streams in the basin (Figure 7.6). Figures 7.7 through 7.13 display minimum instream flow levels with measured flows for continuously gaged streams with less than 10 years of record. Where possible representative, wet, dry and average years were identified to present a normal range of flows. Minimum instream flows for Kennedy and Goldsborough Creek are shown in Figure 5.9 and 5.10 along with the 10%, 50% and 90% exceedance hydrographs.

Both annual and July through September statistics were completed for Kennedy and Goldsborough Creek (Table 7.7). Both creeks are shown to have flows below instream flow levels between 50% and 60% of their period of record. The summer months (July through September) show an increased percentage of the record below instream flows, and that the continuous number of days below instream flow levels is longer.

The periods of record for Kennedy and Goldsborough Creeks are from 1960 to 1971, and 1951 to 1971, respectively. These streams are not currently gaged so there is no means of assessing to what degree minimum instream flows are currently being met. There has been no evaluation of land uses during the periods of record, although forest harvest is expected to have been developed to a similar degree as it currently is. The period of 1947 to 1974 was a wet period as influenced by the Pacific Decadal Oscillation (Figure 5.2). Changing land use patterns such as urbanization has not been assessed.

8. ACTUAL WATER USE

Water use estimates for current and future conditions are a required element of watershed planning under Chapter 90.82 RCW. The types of water use that will be evaluated by category for this watershed are as follows:

- Public water supplies (purveyor water use)
- Individual households (as exempt wells)
- Non-residential public water supplies
- Agricultural irrigation

Some synthesis of the components of water use is necessary to understand water use. Watershed planning typically focuses on the water balance and the way that humans affect it through water use.

8.1 Background Issues

Background water use issues are a combination of regulatory and technical issues. Issues related to water use include:

- Water use can be consumptive or non-consumptive
- The primary consumptive water use in the watershed is from individual households on public water supply systems or individual households on self-supplied systems
- Many individual households are not on public water supply systems and use "exempt wells" as a water source. To better understand the effects of "exempt wells" on ground water resources an estimation of their number, their spatial distribution, and the amount of water consumptively used needs to be understood
- Other categories of water use in the watershed evaluated are agricultural irrigation and non-residential public water supply
- There are some other types of water use that are considered as self-supplied commercial/industrial, however since there are no existing data available to estimate actual water use, this category of water use is not evaluated at this time

8.2 Objective and Level of Detail

The objective of this section is to estimate actual water use based on available data and provide the planning unit with a tool adequate to determine the relative amount of water use in the watershed. The actual use estimate will help to determine the level of water availability for future allocation. Current estimated water use in the watershed based on available data is aggregated according to the four sub-basins.

8.3 Assumptions

8.3.1 Purveyor Water Use

Purveyors are entities that provide water to the public and private sector and may include municipalities, water districts and private water systems. This report will include in the term purveyor, all public water systems (PWS), which include municipalities, water districts and privately owned public water systems that provide domestic water to two or more services. A PWS is one that the Department of Health (DOH) defines as any domestic water supply serving more than a single-family residence.

For the purposes of this assessment, purveyor water use will include all public water systems as defined by the DOH as Group A Community water systems, and all Group B water systems.

In general, purveyor water use is comprised of two components; a low consumptive use, "base use", component characterized by water that is returned to the hydrologic system through wastewater treatment plants and septic systems, and a high consumptive use, "peak use", component in the form of irrigation of landscaping and home gardens. Purveyor water use is typically expressed on a per capita basis and a peaking factor is commonly used to represent the increase in outdoor watering during the summer.

8.3.1.1 Base Use

The low-consumptive component is considered base use for the purpose of this discussion. Year-round base use is generally for interior use and therefore almost all the water is returned to the hydrologic system via a wastewater treatment plant or septic system. Base water use is usually fairly consistent throughout the year. Generally, water use during the non-growing season, October through March, can be a good indicator of base water use. However, within this watershed, discharge from wastewater treatment plants is to marine waters, therefore indoor use in sewered areas is more consumptive than in non-sewered areas where at least a portion of the water soaks back into the ground through septic systems.

8.3.1.2 Peak Use

During the months of April through September, water use increases substantially. The increased water use is commonly discussed in terms of peaking factor. A typical peaking factor is approximately two times the base, indoor per capita usage. These peak summer water uses above base water use are mostly assumed to be outdoor use, including lawn watering, car washing and other outdoor uses. Outdoor water use comprises a significant consumptive use of water in the form of being lost to evaporation, soil wetting, evapotranspiration etc.

8.3.1.3 Wastewater Return

Residential water, which comprises the majority of water use in this watershed, is commonly used in interior, lower consumptive use, and higher consumptive exterior use. Interior use is usually discharged to septic systems or wastewater treatment plants. Exterior use is usually used for lawn and garden irrigation in which some of the water is evaporated, and some of the water is recharged to groundwater. Wastewater effluent is not considered in this Level 1 Assessment although an understanding of the relative contributions of wastewater facilities may be important in sub-basins selected for further assessment. Residences without public water service, and therefore on exempt wells, typically do not have sewer service and use septic systems. The return of wastewater from exempt wells to septic systems may offset a significant portion of potential impacts to shallow aquifers.

8.3.2 Exempt Well Water Use for Individual Households

Exempt wells are an important factor in watershed planning because the total number of wells and quantity of water they withdraw is not well known. Wells described as exempt wells are exempt from the requirement to obtain a water right from the Department of Ecology under Chapter 90.44 RCW. RCW 90.44.050 says in part, "any withdrawal of public ground waters…for single or group domestic uses in an amount not exceeding five thousand gallons per day…shall be exempt from the provisions of this section…"

Individual household water supplies from surface water sources are not exempt from the requirement to obtain a water right, and as such individual household surface water uses should be included in Department of Ecology water right/claims records.

Although exempt wells are allowed to use up to 5,000 gallons a day, which is equivalent to a maximum annual use of 5.6 AF/yr, individual household use usually is a much smaller annual amount.

Items affecting water use from exempt wells include:

- Population;
- Base water use;
- Peak water use;
- Net consumptive use; and
- Return flows (commonly through septic systems).

The methods used to estimate the number of exempt wells and their quantity of water used typically assume that the population outside of the service areas of purveyors is served by exempt wells. Exempt well water use patterns typically are similar to public water supply systems. However, higher or lower use patterns are possible from exempt wells.
Variables contributing to higher water use from exempt wells include:

- Since exempt wells are not metered and therefore have no meter charges for water used, as there is for most water supplied from public water systems, there is less incentive to conserve water
- Exempt wells occur in rural areas with some larger lot sizes. Therefore landscaping and garden use can be higher for the larger lots than in more developed areas;

- Exempt wells occur in rural areas that commonly have livestock that use water from these wells.

Variables contributing to lower water use from exempt wells include:

- Exempt wells may be installed in less productive aquifers which limit the volumes of water that can be withdrawn.
- Exempt wells may support homes in rural areas that do not have any landscape water needs.
- Some exempt wells provide water to vacation homes, with smaller lot sizes and/or less than continuous year-round usage

8.3.3 Non-residential Public Water Supplies

Some Group A public water supply systems are classified as noncommunity water systems. There is no similar categorization of public water supply for Group B systems, so all Group B systems are considered to be for residential or community use. Noncommunity water systems are further defined by the Department of Health as follows:

- Non-Transient Non-Community (NTNC) water system-provides service opportunity to 25 or more of the same nonresidential people for 180 or more days within a calendar year.

Examples of NTNC systems are schools, day care centers, businesses, factories, motels, or restaurants with 25 or more employees on-site

- Transient Non-Community (TNC) water systems serve:
  - 25 or more different people each day for 60 or more days within a calendar year;
  - 25 or more of the same people each day for 60 or more days, but less than 180 days within a calendar year; or
  - 1,000 or more people for two or more consecutive days within a calendar year

Examples of a TNC might include a restaurant, tavern, motel, campground, park, RV park, vacation cottage, rest area, fairgrounds, public concert facility, special event facility, or church.

8.3.4 Agricultural Irrigation

Agricultural Census and land zoning information from 1997 USDA data indicate that there is very little irrigated agriculture in Mason County and Thurston County, which are the two counties that have land within WRIA 14. This data source reports the total number of irrigated acres by county. Mason County is shown to have a total of 382 irrigated acres and Thurston County is shown to have a total of 5,564 irrigated acres.

The majority of the land within WRIA 14 is in Mason County, with a small portion of the land within this WRIA being in the northwestern corner of Thurston County. Of the total 244,160 acres in WRIA 14, 208,640 acres or 85 % is in Mason County, and 35,520 acres or 15 percent, is within Thurston County.

The total areas of Mason and Thurston County are 592,640 and 456,960 acres, respectively. Agricultural irrigated acreage in Mason County represents approximately only 0.064% of the land area in the county. Thurston County has much more irrigated acreage than Mason County, both in total acres and in percentage of total land that is irrigated, however irrigated acreage in Thurston County is still relatively small and represents only approximately 1.2 % of the land area in the county.

The geographic distribution of irrigated agricultural land within the two counties or within the WRIA cannot be determined accurately with currently available data. A reasonable method to estimate irrigated acres in Mason County within WRIA 14 is to assume an equal distribution of irrigated acres within Mason County. This results in an estimate for Mason County of total irrigated acres within WRIA 14 to be 0.064 percent of 208,640 acres, or 134 acres.

For Thurston County, a reasonable approach to estimate the irrigated agricultural land is to assume that the percentage of irrigated land within the Thurston County portion of this watershed, which is essentially the Kennedy Sub-basin, is the same percentage as the Mason County portion of this watershed. This assumption is based on the land use within the Kennedy Sub-basin as more representative of land use in Mason County, than Thurston County. Using this assumption the number of irrigated acres in Thurston County for this watershed would be 0.064 percent of 35,520 acres, or 23 acres.

The total estimated number of irrigated acres in the watershed is 134+23=157 acres, as shown in the following table.

Irrigated Acres in WRIA 14

County	Total Acres in County	Total Acres in WRIA 14	Total Irrig Acres in County	% Of Irrig Acres in County	Irrig Acres in County in WRIA 14
Mason	592,640	208,640	382	0.064	134
Thurston	456,960	35,520	5,564	1.2	23
Total	1,049,600	244,160	5,946		157

Due to the relatively small amount and the assumed diffuse distribution of acreage in irrigated agriculture, water use for agricultural irrigation will not be further characterized into individual sub-basins. In addition, no estimate will be made in this report for projected water use for this type of water use. For estimating purposes at this time, it is assumed that agricultural irrigation would continue at the same level.

8.4 Methodology

Residential water use is typically estimated using population data and per capita water use. The typical approach used is to start with total population represented by the most recent population data, which is the year 2000 census data. The proportion of the population served by public water systems (PWS) is estimated based on data from current Water System Plans for the area or as provided by the Department of Health (DOH) for PWS. A public water system is one DOH defines as any domestic water supply serving more than a single-family residence. The remaining population is then assumed to be on exempt wells. The following data sources were used for this analysis:

- PWS GIS coverage and database information from DOH;
- 2000 Census total population data;
- 2000 Census number of residents per household by county; and,
- City of Shelton Water System Comprehensive Plan, 2001

8.4.1 GIS Treatment of Population

The number of people within each sub-basin served by public water systems was based on DOH data for Group A and B PWS.

PWS point coordinates, representing sources for the systems, are the only spatial data contained in the DOH database.

The locations of PWS were represented by their sources. For water systems with multiple sources, all connections were attributed to the first source listed in the database. This methodology places the use of water at the same location as where it is withdrawn or diverted.

8.4.1.1 Total Number of people within each sub-basin

The total number of people (population) within each sub-basin was determined through the use of a Geographic Information System (GIS), using population data from the US Census Bureau. The population data from the Census Bureau was distributed by census blocks overlays of each of the sub-basins. More detailed information on the determination of the number of people within each sub-basin is found in Section 4.5**(Check on this reference)**

8.4.1.2 Total Number of people on PWSs

The total number of people on PWSs was determined from the DOH PWS data by summing the number of people being served by Group A Community and all Group B public water systems by sub-basin.

8.4.1.3 Total Number of people on exempt wells

The typical method of determining an approximate number of people on exempt wells is to subtract each sub-basin's population served by purveyor systems from the population of the sub-basin. This is based on the general assumption that all persons not supplied by a purveyor are supplied by an exempt well.

8.4.2 Purveyor Water Use

An average per capita residential water use rate of 120 gallons per day was used in the June 1997 Jefferson County Coordinated Water System Plan for all public water supply systems in the County except for the City of Port Townsend. There are no similar plans or reports available for rural Mason County.

In the Phase II Level 1 Watershed Planning Assessment Report for the Kitsap WRIA 15, values used were 115 gallons per capita per day (gpdpc) for sub-basins in Kitsap County and 142 gpdpc for sub-basins in Mason and Pierce Counties. The 115 gpdpc for sub-basins in Kitsap County was based on information from the City of Bremerton Comprehensive Plan. The 142 gpdpc was based on information from the Gig Harbor Comprehensive Water System Plan.

Based on the limited data available, the amount of 120 gpdpc as used in the June 1997 Jefferson County Coordinated Water System Plan, was used as a reasonable number for estimating purveyor water use for the Phase II Level 1 assessment for all of WRIA 16. This was based on the use of water in the majority of WRIA 16 being more similar to water use in the Jefferson County Water System Plan, than the water use in the Bremerton and Gig Harbor service areas.

Water use in the rural areas of WRIA 14 is likely similar to WRIA 16, where 120 gpdpc was used for estimating actual water use.

The City of Shelton water use needs to be evaluated independently from the other community water systems in this watershed because of the data that is available and the fact that per capita water use may be higher because of the several large water users within the City service area. As stated in the City of Shelton 2001 Water System Comprehensive Plan, during the year 2000, average water consumption for the 12 largest water users amounted to 21 percent of the total average water consumption. Because of this large amount of water use within the City of Shelton service area that is not for residential use, the per capita water use within the Shelton service area is higher than it would be if there was only residential water use.

The Water System Comprehensive Plan contains water use and water production data for the four-year period from 1997-2000. The data show average day consumption for the area served by the City of Shelton during the four-year period from 1997-2000 as 1,120,000 gallons per day. Based on a service area population of 9,062 and an average use of 1,084,892 gallons per day for the year 2000, the average daily per capita water usage was 120 gpdpc.

Water production data for the four-year period is calculated in the Comprehensive Plan by using 29 percent as lost and unaccounted for water. Using these data and calculations results in an average demand that the City is using for planning purposes through the year 2010 of 188 gpdpc. This 29 percent as lost and unaccounted for water, was determined by a combination of actual source meter data and calculations for water demand during the year 2000. For the years 2011 through 2020, this projection is reduced to 174 gpdpc based on reducing the lost and unaccounted for water to 19 percent.

Because the City of Shelton has supporting data and calculations showing a water demand of 188 gpdpc, and because the City is using this number for their projected water demand through the year 2010, this is the number that should be used for the City of Shelton service area for the purposes of this assessment.

Based on the above, an amount of 120 gpdpc will be used to estimate actual water use for all sub-basins within WRIA 14, except for the portion of the Goldsborough Sub-basin served by the City of Shelton. For the area served by the City of Shelton an amount of 188 gpdpc will be used.

Total purveyor water use by sub-basin was calculated by multiplying the per capita water use rate by the number of people on purveyor systems within a respective sub-basin.

8.4.3 Exempt Well Residential Water Use

The normal method for estimating the number of exempt well water users in a watershed is described above in 8.4.1. This involves subtracting the number of people on purveyor systems from the population of the sub-basin with the number of people remaining to be supplied by exempt wells.

Using the same methodology used to calculate water use by the population on purveyor systems, the amount of water used by persons on exempt wells can be calculated. For estimation purposes in Phase II Level 1, it is assumed that the per capita residential water use for exempt wells is the same as the per capita water use of 120 gallons per day used for PWS.

8.4.4 Non-residential Public Supplies Water Use

All public water supply uses for Group A noncommunity, are included in this category, with the number of systems, connections and population served from data provided by DOH. This category of water use includes multiple types of facilities, some of which are considered as transient and some as nontransient. The number of systems, connections, and population served from these systems are not included in the calculations to determine the population being served by exempt wells, since these systems do not serve residences.

For purposes of this assessment, it is assumed that connections in Group A noncommunity systems use approximately one half the amount of water on an annual basis used by community connections, based on experience that this is a reasonable estimate of water use for these types of water uses. Translating this to daily uses means that 60 gpdpc would be used instead of 120 gpdpc. This means that for an estimated 2.6 persons per household, based on the Group A community water systems data, a factor of 156 gallons per day per connection will be used for Group A noncommunity systems.

8.5 Current Water Use Estimates

This section discusses water use estimates for the WRIA. Consumptive use versus non-consumptive use of water is not quantified in this assessment. Water returned to the hydrologic system via septic systems or other means may need to be estimated in Phase II Level 2 to gain a better understanding of the consumptive water use in the watershed.

Transfers of water between sub-basins were also not accounted for in this assessment but should be addressed in Level 2 due to the effect on the water budget in sub-basins where this occurs.

8.5.1 Purveyor Water Use

According to DOH records, there are a total of 77 Group A community and 439 Group B public water systems within WRIA 14. Table 8-1 shows the number of Group A community and Group B public water systems and the residential population for each of the four sub-basins considered in this report for WRIA 14.

The highest number of Group A community and Group B public water systems is in the Goldsborough Sub-basin, with a total of 30 and 179 systems respectively. The Case Sub-basin closely follows with 27 and 173 systems respectively. The lowest number of Group A community and Group B public water systems is in the Skookum Sub-basin, with seven Group A community and 38 Group B public water systems.

The largest residential population served by Group A community water systems is in the Goldsborough Sub-basin with a total of 17,251. The Case Sub-basin, which has nearly as many systems, only serves a population of 6,536. The largest residential population served by Group B public water systems is in the Case Sub-basin with a total of 1,827. The smallest residential population served by Group A and Group B public water systems is in the Skookum Sub-basin, with 1,384 served by seven Group A systems, and 348 served by 38 Group B public water systems in the sub-basin.

Population data by sub-basin is shown in Table 8-2 for the 1990 and 2000 census. The largest population for the year 2000 is in the Goldsborough Sub-basin, with a total of 24,663. This is nearly four times the next largest population of 6,307 in the Kennedy Sub-basin. The smallest population for the year 2000 is in the Skookum Sub-basin, with a total of 3,285.

The largest city in the watershed, the City of Shelton and its' surrounding area, is located in the Goldsborough Sub-basin. The population of 9,062 served by the City during 2000 subtracted from the total population of 24,663 for the year 2000 population of the Goldsborough Sub-basin, results in a population of 15,601 in this sub-basin not being served by the City.

By comparing the public water systems data shown in Table 8-1 and the census data shown in Table 8-2, it is noted that in the Case Sub-basin the residential population being served by public water systems exceeds the census data. There are several reasons that this apparent error could occur.

It is expected that the primary reason for this is because many of those included as being served by the public water systems are only occupants during part of the year and are not included in the census data, since this is not their primary residence. This apparent error can occur for Group A systems classified as Community (essentially full-time residents) by DOH because a single classification is used for an entire water system, and some residents are part-time and others are full-time residents. Those systems classified as Noncommunity are not included in this total.

This total population served by Group A community water systems is further increased by all the Group B systems, since no breakdown between Community and Noncommunity is made by DOH for Group B systems. Although no classification is made, many of those served by Group B systems are either non-residents or part-time residents.

In addition, potential errors could occur in the assumptions and calculations made in the determination of the population within each of the sub-basins using census data and census blocks within each sub-basin.

Because of this anomaly for this sub-basin where many of the water users are part-time occupants of properties, it is not realistic in this sub-basin to follow the normal approach described earlier for determining the breakdown between water users on public water systems and water users on exempt wells.

Therefore, until this anomaly and data gap can be investigated more thoroughly and additional data collected, a modified conservative approach will be followed in Level 1 for this sub-basin to determine residential water use from public water supplies and from exempt wells.

In the Case Sub-basin, where the data show that the residential population served by public water supplies exceeds the census data population, the total residential population served by public water supplies will be used as the population for the sub-basin. This method is expected to result in a higher, more conservative estimate of residential water use for this sub-basin, since many of these residents may only spend less than half the year in the sub-basin. For Level 1, there will be no estimate made for the residential population being served by exempt wells in this sub-basin since there are no available data to make this evaluation at this time, even though there are exempt wells in the sub-basin.

In the other three sub-basins, the number of residents from the 2000 census data exceeds the public water supply residential water users by what appears to be reasonable amounts. Therefore it can be assumed that using the differences between these two numbers is a reasonable method to estimate the residential population on exempt wells. This is the standard approach as described above and will be used for these sub-basins (Table 8-3).

Using 120 gallons per capita per day as the average water use for residents on a public water supply for the sub-basins, and 188 gallons per capita per day for the area served by the City of Shelton, Table 8-4 shows a total water use of 4,875 acre-feet per year (AF/yr) for PWS use within WRIA 14. The sub-basin with the highest PWS water use is Goldsborough with 1,291 AF/yr for the sub-basin plus 1,903 AF/yr for the City of Shelton service area. The Skookum Sub-basin is the lowest PWS water use with 225 AF/yr.

Based on the amount of water use per square mile, the highest water use density is in the Goldsborough Sub-basin with 20 AF/yr per square mile, with the least being the Skookum and Kennedy Sub-basins, with 6.1 and 5.6 AF/yr/square miles, respectively.

8.5.2 Exempt Well Residential Water Use

The number of people served by exempt wells was estimated using population data, and the number of people on public water systems. As a result of the accuracy of the data provided and a number of simplifying assumptions used in the analysis of population on public water systems, in the Case Sub-basin the population on public water systems is shown to be greater than the total population calculated for the sub-basin. In fact exempt wells are known to exist in all of the sub-basins. Therefore the DOH data for the number of people on public water systems is likely too high for this sub-basin, so for this estimate the population on exempt wells was assumed to be zero.

The total exempt well water use in this WRIA is estimated at 1,391 AF/year for 10,698 people as shown in Table 8-4. The estimated per capita water use for exempt wells used was the same as for the population on public water systems, of 120 gallons per day. The greatest exempt well water use is shown to be in the Goldsborough and Kennedy Sub-basins of 737 and 452 AF/yr, respectively.

Normalizing water use by people using exempt well water use density, water use per square mile, the uses ranged from 6.9 to 5.5 to 4.6 AF/year/mi^2 for Kennedy, Skookum, and Goldsborough, respectively.

As stated above and for purposes of this estimate, the exempt well water use for the Case Sub-basin is assumed to be zero, since the DOH data show the population served by public water supplies exceeds the population of the sub-basin.

8.5.3 Total Residential/Municipal Water Use

Using the combination of data from DOH records for public water systems and the census data, results in a disparity between these numbers for the Case Sub-basin by showing the total population on public water systems as being higher than the entire sub-basin population, as described above. The following approach is shown as another method of determining total residential water use.

Table 8-4 also shows what the total residential water use would be using only the population data as the basis for calculation. This results in a lower amount of water use, 5,845 AF/yr, as compared with 6,265 AF/yr, by using the combination of DOH records and census data. The actual amount of residential water use is likely to be somewhere between these two numbers.

In order to have a common method of projecting estimates of future water use, the residential water use based on the population data will be used as the basis for estimating projected water use, since population data is the only projected data available.

8.5.4 Non-residential Public Water Supplies Water Use

As discussed in 8.3.3 and 8.4.4, this category of water use is for public water supplies that are considered by DOH as Group A noncommunity, which are essentially all Group A uses that are not for residential or municipal use. Using half as the amount of water use per connection, compared to community water use, an amount of 156 gallons per day per connection will be used for this category of water use.

Table 8-5 shows the estimated water use by sub-basin for Group A noncommunity systems. There are a total of 67 noncommunity systems with a total of 944 connections, based on the data provided by the DOH. Using this data and a factor of 156 gallons per day per connection, the total estimated water use for Group A noncommunity water systems is 165 acre feet per year.

8.5.5 Agricultural Irrigation Water Use

Based on the estimated number of irrigated acres in WRIA 14 and using a water duty for Western Washington of 2 acre-feet per acre, the total estimated amount of water use for irrigation of 157 acres in WRIA 14 is 314 acre-feet per year.

8.6 Projected Water Use

Since the primary water use in WRIA 14 is for residential use, including all other types of municipal uses within the City of Shelton service area, this is the only projected water use that will be determined for this assessment.

Projected water use was calculated by determining the projected 2010 population determined in Section 4.5.3.The projected 2010 population for the City of Shelton service area was taken from their 2001 Comprehensive Plan. For purposes of this estimate, the projected water use rates were assumed to be equal to the current water use rates. By applying the projected 2010 population to current water use rates, an estimate of future water use can be calculated. The projected water use estimate only addresses water use based on population. Growth in water use is not broken out between municipal/ purveyor and exempt wells because it is difficult to determine where growth will occur within a sub-basin, if the growth will occur on purveyor systems or exempt wells and how the water supply system would chose to accommodate growth demands. Also, as discussed in 8.5.3, since the PWS data from DOH is not consistent with the census data population for the year 2000, only the existing and projected population data can be compared, so the population data is used for projected water use.

In addition, water use savings as the result of conservation was not investigated or incorporated into the projected water use estimate.

Projected water use was calculated on a per capita basis and not broken out between purveyor systems and exempt wells. Population was anticipated to continue to grow at the same rate as between 1990 and 2000, which was an average of approximately 30% for all of WRIA 14 for the 10-year period.

Projected water use was calculated using the projected 2010 watershed population of 51,134 people. Projected population is discussed in Section ____ and a summary of the estimated projected population for 2010 by sub-basin is presented in Table 8-6. Water use by purveyor residences and exempt wells is projected to be 7,776 AF/yr for 2010 as also shown in Table 8-6. This represents an increase of 1,931 AF/yr as compared to 2000 water use estimates using 2000 population data, as shown in Table 8-4.

8.7 Data Gaps

The following are some identified data gaps related to water use:

- Verification of the DOH data on PWS related to number of residences on each of the PWS
- Information on the number of connections on PWS that are only used on a part-time or vacation basis
- Information on the number of exempt wells that are only used on a part-time or vacation basis
- Information on the total number of exempt wells in the watershed, and within specific sub-basins
- Further evaluation to determine the exact location of PWS and exempt well usage within specific sub-basins
- Information on the actual number of irrigated acres
- Information on self-supplied commercial/industrial water use

9. WATER QUALITY

Fecal coliform contamination is a serious concern in WRIA 14, which is a major shellfish growing area for commercial and public harvesting. North Bay and Oakland Bay shellfish areas are in threat of downgrades due to fecal coliform contamination. The State Department of Health and the Department of Fish and Wildlife are concerned about poor water quality in Hammersley Inlet, North Bay and Oakland Bay. Several initiatives are in place and being pursued to address these issues, some of which are mentioned below in Existing Data.

The City of Shelton wastewater treatment facility has some major problems related to the wastewater collection system. The collection system receives large amounts of inflow and infiltration particularly in the downtown area where the sewers date from around 1910. During heavy rains backups and overflows impact Goldsborough and Shelton Creeks and stress the treatment facility. These sewer overflows, as well as stormwater and failing septic system are probable contributors to fecal coliform contamination in Shelton Harbor. The City is currently embarking on an extensive sewer collection system replacement program in the downtown area that will provide major improvements to these problems that have occurred over many years.

The North Bay/Allyn area has suffered shellfish impacts in the past, which has led to the planning and construction of a wastewater collection and treatment system for this area. The system is being constructed and will be owned and operated by Mason County and will discharge to the ground.

The Hartstene Point Wastewater Treatment Plant and outfall have contributed to the decertification of a valuable geoduck tract on the north side of Hartstene Island. Design and construction of a new outfall is underway so that this geoduck tract can again be certified for harvest.

9.1 Surface Water Quality

This section provides a general summary of existing information pertaining to the condition of surface water quality in WRIA14. According to RCW 90.82.090, the following are items for inclusion in the optional water quality component of watershed planning.

- An examination based on existing studies conducted by federal, state, and local agencies of the degree to which legally established water quality standards are being met in the management area;
- An examination based on existing studies conducted by federal, state, and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and non-point sources of pollution, and pollution-carrying capacities of water bodies in the management area. The analysis shall take into account seasonal stream flow or level variations, natural events, and pollution from natural sources that occurs independent of human activities;
- An examination of the legally established characteristic uses of each of the non-marine bodies of water in the management area;

- An examination of any total maximum daily load established for non-marine bodies of water in the management area, unless a total maximum daily load process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060;
- An examination of existing data related to the impact of fresh water on marine water quality;
- A recommended approach for implementing the total maximum daily load established for achieving compliance with water quality standards for the non-marine bodies of water in the management area, unless a total maximum daily load process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060; and
- Recommended means of monitoring by appropriate government agencies whether actions taken to implement the approach to bring about improvements in water quality are sufficient to achieve compliance with water quality standards.

As of the time of this report, no TMDLs have been completed and approved by the EPA for WRIA 14 water bodies. There are also no TMDLs in the process of being developed in this WRIA.

9.1.1 Objective and Level of Detail

This Level 1 Assessment focuses on summarizing existing surface water quality information within WRIA 14. Assessment of the existing data on the quality of ground water resources is contained in Chapter 10. The information in this assessment of surface water quality includes:

- A summary of Washington State designated waterbody classifications, uses, and state water quality standards;
- A description of waterbodies within the WRIA in which legally established water quality standards are not being met (as identified in Washington State's 1998 list of impaired and threatened waterbodies);
- A description of the pollutants affecting the waterbodies in the WRIA;
- A summary of ongoing TMDL (total maximum daily load) studies and approved TMDL water quality clean up plans within the WRIA; and,
- An identification of data quality and quantity and potential data gaps.

9.1.2 Existing Data

There are many sources of existing data relating to surface water quality in this watershed. A completed bibliography of material is included in Chapter XX References. Oakland Bay/Hammersley Inlet and Little Skookum Inlet each have a Watershed Assessment prepared by the Squaxin Island Tribe. Shellfish Protection Initiatives developed by Thurston County are in place for the Thurston County portions of the Totten/Little Skookum Inlet Watershed and Eld Inlet Watershed. Oakland Bay has a Watershed Management Plan.

9.1.3 Waterbody Classification

Surface waters in the state of Washington are classified into one of four classes with respect to water quality criteria: AA (extraordinary), A (excellent), B (good), and C (fair) according to the intended use of the waterbody (WAC 173-201A-030). Each classification contains water quality criteria needed to support the variety of stream or stream segment designated uses (Parametrix 2001).

There are no major rivers or streams (surface waters) in WRIA 14 that are listed in WAC 173-201A-030 with specific classifications. As stated in WAC 173-201A-030, all unclassified surface waters that are tributary to Class AA waters are classified as Class AA and all other unclassified waters are classified as Class A.

All lakes are classified as Lake Class, and tributaries to lakes, which are not specifically otherwise classified, are classified as Class AA. All other unclassified surface waters are considered to be Class A.

Marine waters in WRIA 14 that are listed in WAC 173-201A-040 with specific classifications include the following:

- Westerly portions of Oakland Bay (inner Shelton Harbor) as Class B,
- Totten Inlet and Little Skookum Inlet as Class AA,
- South Puget Sound west of Brisco Point and west of the northern tip of Hartstene Island as Class A, except as otherwise noted,
- South Puget Sound east of Brisco Point and east of the northern tip of Hartstene Island as Class AA, except as otherwise noted.

A general requirement of Class AA waters is that "the water quality shall markedly and uniformly exceed the requirements for all or substantially all uses". A general requirement of Class A and Lake Class waters is that the water quality shall meet or exceed the requirements for all or substantially all uses". A general requirement of Class B waters is that the water quality shall meet or exceed the requirements for most uses. (WAC 173-201A-030).

9.1.4 Beneficial Uses

Beneficial uses are defined broadly as "uses of water for domestic, stock watering, industrial, commercial, agricultural, irrigation, hydroelectric power production, mining, fish and wildlife maintenance and enhancement, recreational, and thermal power production purposes, and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the state" (WAC 173-500-050).

Characteristic uses of Class AA, Class A, and Lake Class waters include:

- Water supply (domestic, industrial, agricultural);
- Stock watering;
- Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting, other fish migration, rearing, spawning, and harvesting, clam, oyster, and mussel

rearing, spawning, and harvesting, crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting;

- Wildlife habitat;
- Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment);
- Commerce and navigation.

Characteristic uses of Class B waters include:

- Water supply (industrial and agricultural);
- Stock watering;
- Fish and shellfish;
  - Salmonid migration, rearing, and harvesting,
  - Other fish migration, rearing, spawning, and harvesting,
  - clam, oyster, and mussel rearing and spawning,
  - crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting
- Wildlife habitat;
- Recreation (secondary contact recreation, sport fishing, boating, and aesthetic enjoyment); and,
- Commerce and navigation.

9.1.5 State of Washington Water Quality Standards

Water quality standards for surface water are assigned based on the classification of the waterbody as described above. Standards for water quality vary between the assigned classes and among fresh and marine waters. Water quality standards for parameters in Class AA and Class A freshwater streams and Lake Class are listed in Table 9-1. Marine water quality standards for Class AA, A, and B waters are listed in Table 9-2

In determining water quality standards for areas in which waters of two different classes meet, the water quality criteria for the higher classification shall prevail at the boundary between waters of different classifications. In addition, in brackish waters of estuaries, where the fresh and marine water quality criteria differ within the same classification, the criteria shall be applied on the basis of vertically averaged salinity. The freshwater criteria shall be applied at any point where ninety-five percent of the vertically averaged daily maximum salinity values are less than or equal to one part per thousand. Marine criteria shall apply at all other locations; except that the marine water quality criteria shall apply for dissolved oxygen when the salinity is one part per thousand or greater and for fecal coliform organisms when the salinity is ten parts per thousand or greater.

9.1.6 Shellfish Harvesting Standards

The National Shellfish Sanitation Program (NSSP) requires a shoreline survey and a growing area standard to classify a shellfish growing area. The shoreline survey locates and evaluates all significant point and non-point pollution sources along the shorelines and in upland drainage areas. The growing area standard is based on the following water quality criteria:

- The geometric mean of fecal coliform (FC) data shall not exceed 14 per 100 mL; and,
- The 90th percentile of the FC data shall not exceed 43 per 100 mL

A minimum of 30 samples is required from each sampling station to determine the required statistics. Samples are taken six times a year from “Approved” areas and once a month from “Conditionally Approved” areas. Both criteria must be met in order to be compliant with the Growing Area Standard (DOH 1999a, Parametrix 2001).

9.1.7 List of Impaired or Threatened Waterbodies (303 (d) List)

Under Section 303(d) of the Clean Water Act, the Washington Department of Ecology (Ecology) identifies waterbodies that do not meet water quality standards. This list is known as the List of Impaired or Threatened Waterbodies (303(d) list; was most recently updated in 1998 by the Department of Ecology (Table 9-3 and Figure 9.1). An update to the 303(d) list is scheduled for release in 2002.

Four marine waterbodies and 10 freshwater waterbodies are listed as having water quality impairments in WRIA 14. Some of these waterbodies are listed multiple times for the same water quality impairment, since there are multiple locations for some of the waterbodies. All four of the marine waterbodies are listed as impaired for fecal coliform, with Case Inlet and Dana Passage also listed for dissolved oxygen. Of the 10 listed freshwater bodies, five are listed for fecal coliform, three are listed for pH, and two are listed for both fecal coliform and pH. All of these listings will require TMDL development at some time unless water quality improves to the point that they can be delisted.

9.1.8 Pollutants

A predominant parameter exceeding state water quality standards in the freshwater impaired waterbodies of WRIA 14 is fecal coliform. As stated above there are also listings for pH and dissolved oxygen. Although there are many additional pollutants that can cause impairment to water quality standards, including, temperature, total phosphorous, and turbidity, none of these parameters are shown as the basis for listing on the 303(d) list in WRIA 14. Since none of these other common parameters are the basis for 303(d) listing in WRIA 14, they will not be addressed further in this Phase II, Level 1 report.

9.1.8.1 Fecal Coliform

Fecal coliform is the most widespread pollutant affecting waterbodies in WRIA 14. Waterbodies that have documented exceedances of state water quality standards for fecal coliform and require the development of a TMDL are:

- Burns Creek;
- Campbell Creek;
- Case Inlet and Dana Passage;
- Goldsborough Creek;
- Hammersley Inlet;
- Oakland Bay;
- Pierre Creek;
- Shelton Creek;
- Shelton Harbor (Inner);
- Skookum Creek; and,
- Uncle John Creek.

Fecal coliform (FC) bacteria are a type of coliform bacteria. Coliform bacteria are a group of microorganisms found in the feces of all warm-blooded animals, although these bacteria are not unique to feces. In water, coliform organisms are typically used as an indicator of the potential presence of disease-causing organisms. The presence of FC in water indicates the potential microbial degradation of water, and although FC do not affect fish or shellfish themselves, shellfish do retain these microorganisms through the process of filter feeding. Human consumption of shellfish from areas contaminated with FC can create a possible health risk (Parametrix, 2001).

9.1.8.2 pH

pH exceedances are the second largest reason for water quality impairments in WRIA 14. Waterbodies that have documented exceedances of state water quality standards for pH and require the development of a TMDL are:

- Burns Creek;
- Kennedy Creek;
- Perry Creek;
- Pierre Creek; and,
- Schneider Creek

pH is a measure of the acidic or basic nature of a solution on a scale of 0 to 14. The pH of neutral solutions, such as pure water, is equal to 7. Alkaline solutions will have high pHs (8-14), and acidic solutions will have low pHs (1-6). The most common cause of exceedance of pH water quality criteria is the influence of photosythetic processes. Invasion by exotic plants such as milfoil or algal blossoms caused by high nutrient concentrations will cause wide daily fluctuations of pH. During the day when photosynthesis is occurring, the plants produce oxygen that raises the pH above 8. During the night, the plants undergo respiration producing carbon dioxide and lowering the pH below 6.

One of the most significant environmental impacts that pH can have is its effect on the solubility and thus the bioavailability of other substances. Runoff from agricultural, domestic, and industrial areas may contain iron, lead, chromium, ammonia, mercury, or other elements. The pH of the water affects the solubility of these substances. A decrease in pH can increase metal availability in the system, lending itself to greater metal uptake by organisms. Metal uptake can cause extreme physiological damage to aquatic life (Connell and others 1984). Acidic inputs from non-point sources such as acid mine drainage and wet/dry acid deposition, can substantially lower the pH of a system to an acidic level. Table 9-4 lists the effects of various pH levels on aquatic life.

9.1.8.3 Dissolved Oxygen

There is only one listing for dissolved oxygen impairment in WRIA 14, Case Inlet and Dana Passage, which will require the development of a TMDL.

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. Oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The amount of oxygen that can be held by the water depends on a variety of factors including salinity, pressure, and temperature (i.e. colder water holds more oxygen) (Smith 1990). Depletion of oxygen from an aquatic system can occur when water temperatures rise, when plants and animals respire, and with an introduction of excess organic matter. Prolonged exposure to low dissolved oxygen levels (less than 5 to 6 mg/l) may not directly kill an organism, but will increase its susceptibility to other environmental stresses (Gower 1980). The DO acute lethal limit for salmonids is at or below 3 mg/l (EPA 1986, Parametrix 2001).

9.1.9 Trends

Surface water quality trends seem to be positive at this time. This is due to the multitude of efforts that have been completed or are underway to improve surface water quality in the watershed. Effort is being directed to improve surface water quality largely through the reduction of nonpoint pollution due to septic systems and agricultural practices. The efforts being taken by the City of Shelton to upgrade their wastewater collection system will go a long way towards improving the water quality of the lower reaches of Goldsborough and Shelton Creeks, as well as the Shelton Harbor area of Oakland Bay and Hammersley Inlet.

9.2 GROUND WATER QUALITY

This section provides a brief general summary of existing information pertaining to ground water quality in WRIA 14. There is not much data related to ground water quality for the entire WRIA. Overall, the Water Quality Summaries for the 62 Water Resource Inventory Areas of Washington State, released by the Department of Ecology in December 2001 shows that the standards are met for ground water quality in WRIA 14. Information available for specific areas within WRIA 14 is summarized in this section.

9.2.1 City of Shelton

The primary source of existing ground water quality information in this WRIA is from the City of Shelton. Shelton has the largest Group A public water system within this WRIA, and uses three wells and Shelton Springs as their water sources. All Group A public community water systems must comply with the drinking water standards of the federal Safe Drinking Water Act and its amendments. The Washington State Department of Health (DOH) has adopted the federal standards under Chapter 246-290 WAC.

This chapter includes descriptions of the water quality parameters and monitoring requirements necessary to ensure the delivery of safe potable drinking water. The City's

2001 Water System Comprehensive Plan contains a chapter on water quality and several appendices relating to water quality.

Appendix E of the Comprehensive Plan is the City of Shelton's Disinfection Action Plan, dated March 2000. This plan was prepared in response to a directive from the State Department of Health (DOH) that continuous disinfection of the springs will be required. Even though further testing revealed that the Springs is not a Ground Water under the Influence of Surface Water source (GWI), the DOH is requiring that Shelton provide disinfection of all water withdrawn from the Springs.

The Disinfection Plan summarized the water quality data from the City's four sources and it was concluded that the overall water quality of the springs is excellent and the overall water quality of the three deep wells is good, and is typical of other wells in the Puget Sound area. Even though iron and manganese levels are not high in any of the wells, they may be at levels that have been known to result in aesthetic problems such as colored water and staining of fixtures in some other water systems. There is no history of these types of complaints however. No sulfide measurements have been taken, but there have been a few "musty or swampy" taste and odor complaints when Deep Well No. 1 is in operation that indicates that some sulfide may be present. This has not been a problem with Deep Well Nos. 2 and 3.

There are two other recent reports related to the City of Shelton's water sources. The first was titled Hydrogeologic Evaluation of New School Site Near Shelton Springs, July 1999. The second was titled Wellhead Protection Area Delineation for the City of Shelton, September 1999. Each of these reports contains extensive hydrogeologic information for a twelve square mile area with approximately 200 wells in the vicinity of the springs and the City's three deep wells. Even though these reports are an excellent source of hydrogeological information for the area, they contain essentially no information related to ground water quality.

The monitoring requirement for public water sources is the primary means of determining ground water quality. The minimum standards for water quality are expressed in terms of Maximum Contaminant Levels (MCLs). Primary MCLs are based on chronic and/or acute human health effects. Secondary MCLs are based on factors other than health effects, including aesthetics. Some of the parameters that are commonly monitored are

- Bacteriological (Coliform)
- Inorganic elements and compounds
- Volatile organic compounds (VOCs)
- Radionuclides and Radon
- Asbestos
- Lead and Copper

9.2.2 Coliform

The City of Shelton monitors for bacteriological contaminants according to its Coliform Monitoring Plan, and has collected nine routine samples per month for several years. If an unsatisfactory sample occurs, repeat sample are collected.

During the period of time of collecting samples, there is no record of either acute or nonacute coliform violations. One sample taken in July 1998 was unsatisfactory, however the repeat samples did not show coliform, so for reporting purposes no violation occurred.

9.2.3 Inorganic Elements and Compounds

Parameters that are monitored in this category include mercury, arsenic, iron, manganese, nitrate, nitrite, chloride, fluoride, and sulfate. Inorganic chemical (IOC) sampling is required every three years, and nitrate samples are required annually.

Samples taken in 1996-97, and follow-up samples taken in 2000, showed all primary MCLs as being satisfactory for the City's three wells and Shelton Springs.

9.2.4 Volatile Organic Compounds

Volatile organic compounds (VOCs) are manufactured carbon-based chemicals that include many hydrocarbons associated with fuels, paint thinners, and solvents. VOCs are required to be sampled once every three years, unless a waiver is in place.

VOCs have not been detected in any samples collected in recent years from any of the City of Shelton's water sources.

9.2.5 Radionuclides and Radon

Radionuclides include radioactive substances, such as radium and uranium, that occur naturally in subsurface waters. Samples are required to be taken every four years.

Radionuclides samples were collected in July 1998 from all four of the City water sources and all results were well below the trigger for additional testing.

9.2.6 Asbestos

Asbestos is the name for a group of naturally occurring, hydrated silicate minerals with fibrous morphology. Asbestos minerals are mined commercially and because of its' flexibility, strength, and chemical and heat resistance properties, it has many uses, including asbestos cement pipe. The City of Shelton's water distribution system has greater than 10 percent asbestos cement water pipe, so DOH requires an asbestos sample be collected at least once every nine years.

A sample was collected from the water distribution system in July 1998 and the results were well below the MCL requirements.

9.2.7 Lead and Copper

The intention of the federal and DOH Lead and Copper Rule related to lead and copper, is to reduce the tap water concentrations of lead and copper than can occur when corrosion causes lead and copper to leach out from water meters and other plumbing fixtures. Lead and copper sampling can be done only once every three years, provided previous samples meet the requirements.

Samples taken in 1996 and 1999 showed results for both lead and copper to be in compliance with the Lead and Copper Rule.

9.3 Little Skookum Inlet Watershed Assessment

The Little Skookum Inlet Watershed Assessment was prepared in February 1999 by the Squaxin Island Tribe. This report includes information on the watershed relating to natural resources, topography, hydrology, water quality, land use, and issues affecting the natural resources in the watershed.

The boundaries of the Little Skookum Inlet watershed are the same as the Skookum Sub-basin identified as one of the sub-basins in WRIA 14.

The chapter in the report on water quality deals primarily with surface water quality, with only a minor amount of information relating to ground water quality.

Ground water quality in the watershed is primarily influenced by septic systems. Sanitary surveys of residential and commercial septic systems are conducted on an irregular basis by the Department of Health and failing systems are usually corrected within several years.

One of the larger commercial wastewater systems in the watershed is associated with the Squaxin Island Tribe's Little Creek Casino, which has been in existence since September 1995. Following initial treatment adjacent to the casino and convenience store, sewage effluent is pumped to a sand-lined disposal bed on a hill north of the casino. The Tribe and DOH conduct monitoring on a regular basis. Although test results in the septic test wells were higher than anticipated, tests of local domestic wells in the vicinity taken in September 1995 met standards. No additional samples have been taken from the local domestic wells. Water quality in Skookum and Little Creeks has not been noticeably affected since the casino was built, which suggests that the drain field and surrounding soil have effectively filtered nitrogen and fecal coliform from the casino's wastewater facility.

9.4 Oakland Bay/Hammersley Inlet Watershed Assessment

The Oakland Bay/Hammersley Inlet Watershed Assessment was prepared in May 2000 by the Squaxin Island Tribe. This report includes information on the watershed relating to natural resources, topography, hydrology, water quality, land use, and issues affecting the natural resources in the watershed.

The boundaries of the Oakland Bay/Hammersley Inlet watershed are the same as the Goldsborough Sub-basin identified as one of the sub-basins in WRIA 14.

The chapter in the report on water quality deals primarily with surface water quality, with only a minor amount of information relating to ground water quality.

There have been few ground water investigations in this sub-basin. The U.S Geological Survey conducted the most comprehensive investigation in 1970. Chemical analyses was performed on 136 wells and based on these analyses the ground water in the sub-basin was classified as being of good quality.

The only problems identified at the time of the analyses were instances of seawater intrusion on the north and south sides of the entrance to Hammersley Inlet and contamination of wells surrounding Goose Lake. Some wells in the lower Shelton Valley also showed increased chloride levels when pumped heavily, although it was uncertain whether the source was seawater or native saline water within nearby aquifers. Another notation was made in this report that because of the course substrates, the area is susceptible to both ground water and surface water contamination from septic systems.

At the present time the primary threats to ground water quality are septic systems contamination, spills at local businesses, underground fuel tanks, and the Mason County Landfill and Goose Lake dump site. There is little documentation of the impacts from these sources, with most of the current data relating to underground fuel storage tanks. Ecology maintains records on installation, leakage, and removal of underground tanks. Approximately 93 underground storage tanks were being tracked by Ecology as of October 1998, with 10 sites having been involved with ground water contamination and 27 sites suspected of contributing to soil contamination. Most of these sites have been cleaned up or are in the cleanup process.

The Goose Lake dumpsite has been under consideration as a Superfund Site. Wells in this vicinity of the Goose Lake dumpsite have been closed due to poor taste and smell and have tested high for lignins and tannins according to the 1970 USGS report. The aquifer in this area is believed to be associated through abandoned ITT Rayonier wells with another aquifer serving public and private wells within four miles of the lake. Ecology has performed tests in the area that showed that the thresholds for ground and surface water were not exceeded. The tests did show some sediments to be contaminated with heavy metals and organic compounds, so Ecology has recommended additional monitoring under the Superfund program.

10. SUB-BASIN SUMMARIES

The Kennedy-Goldsborough Watershed has been divided into five sub-basins for the purposes of Level 1 Assessment. From north to south, these are:

- South Shore (Hood Canal);
- Case;
- Goldsborough;
- Skookum; and,
- Kennedy.

The Level 1 Assessment of the South Shore Sub-basin has been conducted under the Level 1 Assessment of the Skokomish-Dosewallips Watershed and is not further discussed here. The water balance for the South Shore Sub-basin was developed using the methods applied for the rest of the Kennedy Watershed.

One influence that permeates the assessment of all of these sub-basins is the manner in which the water balance was derived. Because of the lack of stream gaging data in the watershed, water balance relationships are characterized for the Upper Goldsborough and Upper Kennedy stream gaging catchments where there is at least ten years of stream gaging data. These water balance relationships are then extrapolated to the remaining areas. Although the hydrology and hydrogeology vary across the watershed, this approach is considered reasonable when applied at this scale. Actual water balance relationships may locally vary from those derived in this assessment.

Water system characteristics that are expected to have among the largest influences on water balance are the underlying geology and the slope of the land. The Upper Goldsborough reference catchment is underlain predominantly by till (~60%), and smaller areas of sand and gravel (~30%) and bedrock (~10%). The Upper Kennedy catchment is underlain predominantly by bedrock (~75%), and smaller areas of till (~15%) and sand and gravel (~10%). Both of the reference catchments have steep slopes relative to the rest of the basin.

Bedrock results in quick runoff of rain and relatively low groundwater storage. Till usually has high runoff although it can be quite variable. Water that infiltrates through till into underlying strata usually has a greater degree of hydraulic separation from streams. Sand and gravel have higher infiltration rates, but also have a much greater degree of hydraulic continuity with streams in the form of baseflow. Extrapolation of water balance characteristics from the reference catchments to other areas is based primarily on the amount of bedrock present in a sub-basin or catchment.

Actual use estimates are based on population data and agricultural land use census. Commercial and industrial use are estimated from allocation data to be less than 2% in the Case, Skookum and Kennedy Sub-basins, and were not included in the estimates. Approximately 75% of the allocation of water in the Goldsborough Sub-basin is estimated to be for commercial and industrial use, and a estimate of actual use for this purpose was estimated using the ratio of water allocated and actually used for drinking use (i.e., residential, domestic and municipal use). The distribution of actual use between surface water and groundwater was not characterized although it may be similar to the distribution of allocated water between these sources.

Water balance quantities presented in the sections below are taken from Appendix A. A copy of the minimum instream flow regulations is contained in Appendix B (Ch. 173-514 WAC).

10.1 Case Sub-Basin

The Case Sub-basin forms the northernmost sub-basin assessed in this report. It includes the drainage of Sherwood Creek (including Mason Lake) and the islands in this watershed (i.e., Hartstene and Skookum Islands and smaller islands). This sub-basin has the highest ratio of shoreline to land mass in the basin. Precipitation in the Case Sub-basin is the lowest in the watershed averaging 57 inches a year. It has no bedrock outcrops and is covered by an extensive layer of glacial till (hardpan). Population is relatively sparse with concentrations along North Bay, east of Spencer Lake, and in parts of Hartstene Island. It had the lowest recent growth rate of all the sub-basins (23% over the 1990s), and has the lowest population density in the watershed (159 people per square mile) along with the Skookum Sub-basin.

10.1.1 Water Quantity

The annual water balance for the Case Sub-basin is as follows:

Case Sub-basin Annual Water Balance Components

Water Balance Component	**Volume** (AF/yr)	Average Annual Rate (cfs)	**Percent of Total Water**
Precipitation	196,815	272	100%
Evapotranspiration	74,038	102	38%
Streamflow	70,117	97	36%
- as runoff	53,433	74	*76%
- as baseflow	16,684	23	*24%
Underflow	52,660	73	27%

* As a percent of total stream flow

A total estimated allocation of water in this sub-basin is 6,301 AF/yr (8.7 cfs assuming continuous use). Allocations are approximately 95% from groundwater and almost totally for drinking and agricultural irrigation purposes, and are distributed as follows:

Case Sub-basin Summary of Allocated Water
(AF/yr)

Purpose of Use	Groundwater	Surface Water	Total
Commercial Industrial	17	36	53
Drinking (domestic & municipal)	3,242	102	3,344
Agricultural irrigation	2,240	376	2,616
Other	3	105	108
Total:	**5,682**	**619**	**6,301**

The estimated quantity of water actually used in this sub-basin is approximately 1,153 AF/yr, or less than 20% of that allocated. Approximately 95% of this estimated water use is for domestic purpose of use. Although the actual use estimate excludes commercial and industrial use, only 1% of the allocated water is for these purposes of use. Therefore commercial and industrial actual use is not considered significant and the total actual water use is considered reasonable. Allocation of water is concentrated around Mason Lake, the shore of North Bay and along the coast of Hartstene Island (Figure 7.3).

Data from the Department of Health indicate that the number of people on Public Water Systems exceeds the number of people living in this area. Therefore, a reasonable estimate of the population served by exempt wells cannot be made using the approach applied (i.e., subtracting the population served by public water systems from the total population). Unregistered exempt wells are known to exist in this basin and may provide water to a significant portion of the population.

Case Sub-basin Estimate of Actual Use
(AF/yr)

Purpose of Use	Total
Drinking (domestic & municipal)	1,087*
Public Water Supplies	1,087
Exempt Wells	**
Agricultural irrigation	66
Total:	**1,153**

* Maximum number based on Public water System data – actual use may be as low as 667 AF/yr, based on population.

** Estimates of the population served by Public Water Systems exceed the population of the sub-basin. Therefore no reasonable estimate of the population served by exempt wells was obtained.

There are 10 applications for new water rights, eight of which are for groundwater, and all for domestic purpose of use. The oldest (1992-1993) and largest of these applications are for 600 gpm (for domestic and irrigation use) at the mouth of Sherwood Creek, and for 300 gpm (for domestic use only) on Hartstene Island near the bridge with the mainland over Pickering Passage (Figure 7.4).

The various estimated water quantity components of the Case Sub-basin are presented below. In the summary table below, allocation of surface water is compared directly with total streamflow and the runoff component of stream flow because surface water diversions directly impact these. Groundwater allocations are compared directly with baseflows and underflow because groundwater withdrawals may directly affect both of these water balance components. The degree that groundwater withdrawals affect baseflows is variable and is a function of hydraulic continuity, and seasonality of flows and withdrawals and diversions.

Case Sub-basin Water Quantity Summary
(AF/yr)

<table>
<tr><th>Component</th><th>Water Balance Value</th><th>Allocation</th><th>Actual Use*</th></tr>
<tr><td>Precipitation</td><td>196,815</td><td>-</td><td>-</td></tr>
<tr><td>Evapotranspiration</td><td>74,038</td><td>-</td><td>-</td></tr>
<tr><td>Streamflow</td><td>70,117</td><td rowspan="2">619
(surface water)</td><td rowspan="4">1,153</td></tr>
<tr><td>- as runoff</td><td>53,433</td></tr>
<tr><td>- as baseflow</td><td>16,684</td><td rowspan="2">5,681
(groundwater)</td></tr>
<tr><td>Underflow</td><td>52,660</td></tr>
</table>

* Excluding commercial and industrial uses

10.1.2 Stream closures

The lower reach of Sherwood Creek (from Mason Lake to the mouth, including tributaries) is closed to further consumptive appropriation from September 16 to October 31, and minimum instream flows have been established for the rest of the year. If groundwater investigations determine that withdrawal of ground water from source aquifers will not interfere significantly with stream flow during the period of closure or with maintenance of minimum instream flows, then applications to appropriate public waters may be approved and permits or certificates issued (Ch. 173-514-030(6)).

Small streams in the southeast corner of this subbasin (Jones Creek) and on the north end of Hartstene Island (Jarrell Creek) are closed to further consumptive appropriation from May 1 to October 31, including tributaries. Minimum instream flow inside of the closed period is set at the natural flow. Insufficient stream flow data were available to define natural flows or establish numerical minimum instream flow values set outside of these periods. Therefore minimum instream flows for consumptive use will be considered on a case-by-case basis in consultation with the Department of Fish and Wildlife (Ch. 173-514-040(1)).

10.1.3 Water Quality

There are only two listings of impaired water quality in the Case Sub-basin. North Bay is listed for low dissolved oxygen and fecal coliform, while the south end of Hartstene Island is listed for low dissolved oxygen and pH. These water quality problems are of particular concern to the shellfish industry. Mason County is constructing a wastewater collection and treatment system in the North Bay / Allyn area, which should alleviate the water quality problems of this area. Outfall from the Hartstene Island wastewater treatment plant has impacted geoduck tracts on the north side of the island and is being reconfigured.

10.2 Goldsborough Sub-Basin

The Goldsborough Sub-basin is centrally located in the Kennedy-Goldsborough watershed and is the largest sub-basin, comprising 51% of the watershed (excluding the South Shore Sub-basin). It includes the drainages of Goldsborough, Johns, Cranberry Deer and Mill Creeks, as well as the complete drainages of Oakland Bay and Hammersley Inlet. Average annual precipitation is 68 inches a year. The sub-basin is underlain predominantly by till. There are significant areas of sand and gravel in the central part of the sub-basin, and small amounts of bedrock outcrop (6% of the sub-basin) in the southwest corner of the sub-basin where volcanic rocks of the Black Hills extend into the watershed from the south. This sub-basin has the highest population density in the watershed (159 people per square mile). Population is concentrated in the City of Shelton with the largest population blocks immediately north of the city limits, and in the Spencer and Philips Lakes in the east part of the sub-basin. Population growth during the 1990s was representative of the basin as a whole at 29% over ten years.

10.2.1 Water Quantity

The annual water balance for the Goldsborough Sub-basin is as follows:

Goldsborough Sub-basin Annual Water Balance Components

Water Balance Component	**Volume** (AF/yr)	Average Annual Rate (cfs)	**Percent of Total Water**
Precipitation	559,530	773	100%
Evapotranspiration	172,474	238	31%
Streamflow	236,842	327	42%
- as runoff	183,279	253	*77%
- as baseflow	53,563	74	*23%
Underflow	150,215	207	27%

* As a percent of total stream flow

The estimated allocation of water in this sub-basin is 56,338 AF/yr (78 cfs assuming continuous use), which comprises 71% of the total allocation in the Kennedy Goldsborough watershed (less the South Shore Sub-basin). Allocations are approximately equally divided between surface water and groundwater. The majority of this allocated water is for commercial and industrial purposes of use (74%, equally split between groundwater and surface water). The rest of the allocated water is for domestic/municipal use (~15%, 95% of which is from groundwater), and agricultural irrigation use (~10%, split approximately equally between surface water and groundwater).

Goldsborough Sub-basin Summary of Allocated Water
(AF/yr)

Purpose of Use	Groundwater	Surface Water	Total
Commercial Industrial	19,327	22,220	41,527
Drinking (domestic & municipal)	8,207	642	8,849
Agricultural irrigation	1,180	3,229	4,409
Other	263	1,290	1,553
Total:	**28,977**	**27,381**	**56,338**

Estimated actual water use for residential and domestic demand in this sub-basin is approximately 3,931 AF/yr, or 44% of that allocated for this purpose of use. Agricultural irrigation is estimated to use 157 AF/yr. Because commercial and industrial use is a significant component of the allocated water in this sub-basin, an estimate of actual was use and may comprise a significant portion of actual use in this sub-basin, actual use was estimated. The ratio of water allocated to drinking water to commercial and industrial uses is 4.7. Applying the same ratio to actual use for drinking water (4.7 * 3,931 AF/yr) provides an estimated quantity of 18,436 AF/yr for commercial and industrial actual use, which is 44% of that allocated for this purpose of use.

Goldsborough Sub-basin Estimate of Actual Use
(AF/yr)

Purpose of Use	Total
Drinking (domestic & municipal)	3,931
Public Water Supplies	3,194
Exempt Wells	737
Agricultural irrigation	157
Subtotal:	**4,088**
Commercial industrial	18,436
Total:	**22,514**

There are 29 applications for new water rights dating back to 1992, three of which are for surface water. Most of these are in the Johns Creek drainage, with a few in the Cranberry and Deer Creeks drainages. The largest one is for the Department of Corrections (660 gpm) and the Port of Shelton (four applications for 625 gpm; Table 7-5, Figure 7.4). The three applications for the direct diversion of surface water are for fish propagation (0.2 cfs) and domestic use (0.01 cfs). There are seven applications to change existing water rights ranging in age from 1996 to 2002.

The various estimated water quantity components of the Goldsborough Sub-basin are presented below. In the summary table below, allocation of surface water is compared directly with total streamflow and the runoff component of stream flow because surface water diversions directly impact these. Groundwater allocations are compared directly with baseflows and underflow because groundwater withdrawals may directly affect both of these water balance components. The degree that groundwater withdrawals affect baseflows is variable and is a function of hydraulic continuity, and seasonality of flows and withdrawals and diversions.

Goldsborough Sub-basin Water Quantity Summary
(AF/yr)

Component	Water Balance Value	Allocation	Actual Use*
Precipitation	559,530	-	-
Evapotranspiration	172,474	-	-
Streamflow	236,842	27,381 (surface water)	22,514
- as runoff	183,279		
- as baseflow	53,563	28,977 (groundwater)	
Underflow	150,215		

* Excluding commercial and industrial uses

10.2.2 Stream closures

The upper reach of Mill Creek (upstream of Isabella Lake) is closed year-round to further consumptive appropriation. The following creeks are closed to further consumptive appropriation for portions of the year:

- Campbell;
- Uncle John;
- Melaney;
- **Deer*;**
- **Cranberry*;**
- **Johns*;**
- Shelton;
- **Goldsborough*;** and,
- **Mill*.**

Several of these have defined instream flow compliance points (indicated by bold/asterisk above) and have established regulatory minimum instream flows. Although stream gaging may have historically been conducted at some of these defined instream flow compliance points, no gaging is currently being conducted. For the remaining streams, insufficient data was available to establish numerical minimum instream flow values, and minimum instream flow inside of the closed period is set at the natural flow.

Minimum instream flows in Goldsborough Creek are not met approximately half of the time (Table 7-7; Figure 7.8). There have been periods where the minimum instream flow has not been met continuously for almost half a year. In a typical year, flows are not met for two continuous months each summer.

Minimum instream flows have been established on Mill Creek, but there is very little record of actual flows with which to evaluate how frequently actual flows meet regulatory flows (Figure 7.10). It appears that minimum instream flows are not met on the order of 70% of the time, and that the actual low flows are approximately three times lower than established by regulation.

The minimum instream flows for Johns, Deer and Cranberry Creek appear to be representative of average flows. As a result, flows are not met most of the time in dry years, and are met most of the time in wet years (Figures 7.11, 7.12, and 7.13).

If groundwater investigations determine that withdrawal of ground water from source aquifers will not interfere significantly with stream flow during the period of closure or with maintenance of minimum instream flows, then applications to appropriate public waters may be approved and permits or certificates issued (Ch. 173-514-030(6)). Allocations for consumptive use in basins for which minimum instream flows are not established will be considered on a case-by-case basis in consultation with the Department of Fish and Wildlife (Ch. 173-514-040(1)).

10.2.3 Water Quality

There are several listings of impaired water quality in the Goldsborough Sub-basin, all for fecal coliform. Fecal coliform is primarily associated with animal waste (e.g., feed lots and pet waste in stormwater runoff) and human waste discharges (waste water treatment plants and septic systems) although other sources include soil erosion and marine mammals. The listed water bodies are clustered around the junction of Hammersley Inlet and Oakland Bay, including four areas in marine water, and Shelton, Campbell and Goldsborough Creeks. A portion of Hammersley Inlet at the mouth of Mill Creek is also listed.

Overflows from the City of Shelton sewer system impact Shelton and Goldsborough Creeks and the adjacent marine areas. Failing septic systems may also be a significant contributor. The City is currently embarking on an extensive sewer collection replacement program. Supplemental funding under the watershed planning process of WRIA 14 is being applied for to conduct a study of failing water systems and their impacts to the nearshore marine environment. The maintenance of high quality marine nearshore environment is critical to the private commercial and tribal shellfish industry of which there is significant activity in Oakland Bay and Hammersley Inlet.

10.3 Skookum Sub-Basin

The Skookum Sub-basin is the smallest sub-basin assessed in this report (11% of the watershed, excluding the South Shore Sub-basin) and includes the complete drainage of Skookum Inlet and Skookum Creek. Average annual precipitation is 68 inches a year. The surficial geology is comprised of approximately equal amounts of bedrock, till and sand and gravel. The population is concentrated along the south shore of Skookum Inlet along the Kamilche Peninsula, and the north shore of Skookum Inlet. Population is very sparse in the headwaters of this sub-basin. Although population growth in this sub-basin was the highest of the watershed at 43% over the 1990s, it still has the lowest population density along with the Case Sub-basin.

10.3.1 Water Quantity

The annual water balance for the Skookum Sub-basin is as follows:

Skookum Sub-basin Annual Water Balance Components

Water Balance Component	**Volume** (AF/yr)	Average Annual Rate (cfs)	**Percent of Total Water**
Precipitation	120,310	166	100%
Evapotranspiration	37,167	51	31%
Streamflow	60,427	83	50%
- as runoff	49,641	69	*82%
- as baseflow	10,785	15	*18%
Underflow	22,716	31	19%

* As a percent of total stream flow

A total estimated allocation of water in this sub-basin is 2,446 AF/yr (3.4 cfs assuming continuous use), of which 60% is from groundwater. The majority of this allocated water is for irrigation use (~60%), most of which comes from surface water (~60%), while the rest is mostly for drinking water use. Approximately 2% is for commercial and industrial and other use.

Skookum Sub-basin Summary of Allocated Water
(AF/yr)

Purpose of Use	Groundwater	Surface Water	Total
Commercial Industrial	37	0	37
Drinking (domestic & municipal)	927	35	962
Agricultural irrigation	535	899	1,434
Other	3	10	13
Total:	**1,502**	**944**	**2,446**

Estimated actual water use in this sub-basin for residential and domestic demand is approximately 427 AF/yr, or approximately 45% of that allocated for this purpose of use. Agricultural irrigation is estimated to use only 34 AF/yr. Therefore a significant amount of the water allocated for irrigation use may not actually be used. No estimates of actual use for commercial and industrial use were made.

Skookum Sub-basin Estimate of Actual Use
(AF/yr)

Purpose of Use	Total
Drinking (domestic & municipal)	427
Public Water Supplies	225
Exempt Wells	202
Agricultural irrigation	34
Total:	**461**

There are 9 applications for new water rights dating back to 1992, one of which is for surface water. Two applications are within the drainage of Skookum Creek, while the rest of them are along the north shore of Skookum Inlet. The largest of these applications is for 280 gpm for commercial and industrial purpose of use. The single application for surface water is single domestic use (0.02 cfs).
The various estimated water quantity components of the Skookum Sub-basin are presented below. In the summary table below, allocation of surface water is compared

directly with total streamflow and the runoff component of stream flow because surface water diversions directly impact these. Groundwater allocations are compared directly with baseflows and underflow because groundwater withdrawals may directly affect both of these water balance components. The degree that groundwater withdrawals affect baseflow is variable and is a function of hydraulic continuity, and seasonality of flows and withdrawals and diversions.

Skookum Sub-basin Water Quantity Summary
(AF/yr)

<table>
<tr><th>Component</th><th>Water Balance Value</th><th>Allocation</th><th>Actual Use*</th></tr>
<tr><td>Precipitation</td><td>120,310</td><td>-</td><td>-</td></tr>
<tr><td>Evapotranspiration</td><td>37,167</td><td>-</td><td>-</td></tr>
<tr><td>Streamflow</td><td>60,427</td><td rowspan="2">944
(surface water)</td><td rowspan="4">461</td></tr>
<tr><td>- as runoff</td><td>49,641</td></tr>
<tr><td>- as baseflow</td><td>10,785</td><td rowspan="2">1,502
(groundwater)</td></tr>
<tr><td>Underflow</td><td>22,716</td></tr>
</table>

* Excluding commercial and industrial uses

10.3.2 Stream closures

The following creeks are closed to further consumptive appropriation for portions of the year:

- **Skookum*;**
- Little Skookum
- Elson;
- Fawn Lake outlet; and,
- Deer Creek.

Skookum Creek has a defined instream flow compliance point and established regulatory minimum instream flows. Although stream gaging has been historically conducted on Skookum creek, no gaging is currently being conducted. For the remaining streams, insufficient data were available to establish numerical minimum instream flow values, and minimum instream flow inside of the closed period is set at the natural flow.

Regulatory minimum instream flows on Skookum Creek are not met in any year of the available period of record of stream flow data. Typical summer low flows are approximately only 25% of the mandated regulatory flows (Figure 7.9).

If groundwater investigations determine that withdrawal of ground water from source aquifers will not interfere significantly with stream flow during the period of closure or with maintenance of minimum instream flows, then applications to appropriate public waters may be approved and permits or certificates issued (Ch. 173-514-030(6)). Allocations for consumptive use in basins for which minimum instream flows are not established will be considered on a case-by-case basis in consultation with the Department of Fish and Wildlife (Ch. 173-514-040(1)).

10.3.3 Water Quality

The lower reach of Skookum Creek is listed as water quality impaired for fecal coliform.

10.4 Kennedy Sub-Basin

The Kennedy Sub-basin forms the southernmost sub-basin in the Kennedy-Goldsborough watershed and includes the complete drainage of Totten Inlet, the northern drainage of Eld Inlet, and the drainages of Kennedy, Schneider and Perry Creeks. Average annual precipitation is 63 inches a year. The surficial geology is predominantly bedrock (42%) and till (~35%), with smaller amounts of sand and gravel (~25%). The population is concentrated between Totten and Eld Inlets, and is very sparse in the headwaters of this sub-basin. Population growth in this sub-basin was the representative of the watershed as a whole (30% over the 1990s) and the current population density is moderate (118 people per square mile) relative to the Kennedy-Goldsborough watershed.

10.4.1 Water Quantity

The annual water balance for the Kennedy Sub-basin is as follows:

Kennedy Sub-basin Annual Water Balance Components

Water Balance Component	**Volume** (AF/yr)	Average Annual Rate (cfs)	**Percent of Total Water**
Precipitation	178,543	247	100%
Evapotranspiration	60,186	83	34%
Streamflow	93,410	129	52%
- as runoff	79,041	109	*85%
- as baseflow	14,369	20	*15%
Underflow	24,947	34	14%

* As a percent of total stream flow

A total estimated allocation of water in this sub-basin is 3,758 AF/yr (5.2 cfs assuming continuous use), of which 70% is from groundwater. Slightly more than half of this allocated water is for irrigation use. Approximately 1% is for commercial and industrial and other use.

Kennedy Sub-basin Summary of Allocated Water
(AF/yr)

Purpose of Use	Groundwater	Surface Water	Total
Commercial Industrial	34	0	34
Drinking (domestic & municipal)	1,355	303	1,658
Agricultural irrigation	1,228	824	2,052
Other	3	12	15
Total:	**2,619**	**1,139**	**3,758**

Estimated actual water use in this sub-basin for residential and domestic demand is approximately 820 AF/yr, or approximately 50% of that allocated for this purpose of use. Agricultural irrigation use is estimated to 54 AF/yr. No estimates of commercial and industrial use were made.

Kennedy Sub-basin Estimate of Actual Use
(AF/yr)

Purpose of Use	Total
Drinking (domestic & municipal)	820
Public Water Supplies	368
Exempt Wells	452
Agricultural irrigation	54
Total:	**874**

There are six applications for new groundwater rights, and 21 applications for new surface water rights. All of the surface water right applications are for single domestic use with a median volume of 0.02 cfs. Most of the surface water right applications are around Summit Lake and were submitted over the past four years. All of the groundwater water right applications are for multiple domestic purpose of use and are probably associated with housing developments, although in addition to domestic use, two also list irrigation and one also lists commercial industrial as additional purposes of use. The largest of these is for 200 gpm for multiple domestic use only.

The various estimated water quantity components of the Kennedy Sub-basin are presented below. In the summary table below, allocation of surface water is compared directly with total streamflow and the runoff component of stream flow because surface water diversions directly impact these. Groundwater allocations are compared directly with baseflows and underflow because groundwater withdrawals may directly affect both of these water balance components. The degree that groundwater withdrawals affect baseflows is variable and is a function of hydraulic continuity, and seasonality of flows and withdrawals and diversions.

Kennedy Sub-basin Water Quantity Summary
(AF/yr)

Component	Water Balance Value	Allocation	Actual Use*
Precipitation	178,543	-	-
Evapotranspiration	60,186	-	-
Streamflow	93,410	1,139 (surface water)	874
- as runoff	79,041		
- as baseflow	14,369	2,619 (groundwater)	
Underflow	24,947		

* Excluding commercial and industrial uses

10.4.2 Stream closures

Summit Lake, which is tributary to Kennedy Creek, is closed to further consumptive appropriation in order to maintain the level of the lake. The following creeks are closed to further consumptive appropriation for portions of the year:

- **Kennedy*;**
- Schneider; and,
- Perry.

Kennedy Creek has a defined instream flow compliance point and has established regulatory minimum instream flows. Although stream gaging has been historically conducted on Kennedy Creek, no gaging is currently being conducted. For the remaining streams, insufficient data was available to establish numerical minimum instream flow values, and minimum instream flow inside of the closed period is set at the natural flow.

Minimum instream flows in Kennedy Creek are not met approximately 60% of the time (Table 7-7; Figure 7.7). There have been periods where the minimum instream flow has not been met continuously for almost half a year. In a typical year, flows are not met for two continuous months each summer.

If groundwater investigations determine that withdrawal of ground water from source aquifers will not interfere significantly with stream flow during the period of closure or with maintenance of minimum instream flows, then applications to appropriate public waters may be approved and permits or certificates issued (Ch. 173-514-030(6)). Allocations in basins for which minimum instream flows are not established, allocation for consumptive use will be considered on a case-by-case basis in consultation with the Department of Fish and Wildlife (Ch. 173-514-040(1)).

10.4.3 Water Quality

The lower reaches of Kennedy, Schneider and Perry Creeks are listed as water quality impaired for pH. This parameter is usually caused by algal or plant respiration. Algal blooms elevated levels of plant life are commonly supported by elevated influxes of nutrients (e.g., nitrate and phosphorus) such as from fertilizer, animal wastes or human waste (e.g., septic systems).

10.5 Inter-subbasin Comparisons

The amount of water in a sub-basin allocated (or used) as a percent of the water in the hydrologic system is referred to as the relative degree of allocation (or use). The term allocation as used here is the volume of water for which water rights have been issued (as permits or certificates) or for which water rights are claimed. A large basin with the same volume of actual water use will have smaller impacts on its system than a small basin with the same volume of water use. The water balance components, allocation of groundwater and surface water, and estimates of actual use for each sub-basin are compiled for comparison (Table 10-1).

The portion of allocated water rights that are developed and applied to beneficial use is called the "perfected" portion of a water right. The estimated degree of perfection of water rights in each sub-basin is listed in the fourth row of Table 10-1. The undeveloped portion is called the "inchoate" portion.

Estimates of agricultural irrigation use in all sub-basins total 310 AF/yr. Therefore the majority of water allocated for this use (10,700 AF/yr) may not currently be put to its intended beneficial use.

The degree of apparent perfection of water rights in the sub-basins ranges from 18% to 40% across the watershed. This characterization of degree of perfection is a general assessment and actual perfection of water rights is contingent on many factors that are specific to each water right such as its historical use.

The degree to which the water resources are developed in a sub-basin is characterized by comparing the estimated annual volume of actual use to the total flow of surface water and groundwater through each sub-basin. The lowest degree of development is in the Skookum Sub-basin where 0.6% of the total flow in the basin is estimated to be diverted for use. The sub-basin with the highest degree of development is in the Goldsborough Sub-basin where 7.8% of the flow of the sub-basin is diverted for use. A better quantification of the actual use for commercial and industrial purposes may refine the estimated degree of resource use in the Goldsborough Sub-basin.

The allocation of total water resources in each sub-basin varies from approximately 3% (Skookum Sub-basin) to 15% (Goldsborough Sub-basin). The total water resource of the Goldsborough Sub-basin is allocated three to five times more than the other sub-basins relative to the total flow of water through the sub-basins.

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TABLES

TABLE 1-1

Acronym List

°F	Degrees Fahrenheit
abv	above
af/yr, AF/yr	acre-feet per year
amsl	above mean sea level
blw	below
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Oxygen Demand
CD	Cumulative Departure
CE-QUAL-W2	Surface water quality model developed by the US Army Corps of Engineers
cfs	cubic feet per second
cfs/af/yr	cubic feet per second per acre-feet per year
CIR	Crop Irrigation Requirement
CORPS	United States Army Corps of Engineers
CU	Consumptive Use
degrees C	Degrees Celsius
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DNR	Department of Natural Resources
DO	Dissolved Oxygen
Ecology	Washington Department of Ecology
e.g.	for example
EES	Economic and Engineering Services
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ESA	Federal Endangered Species Act
ET	Evapotranspiration
ft	Feet
ft/gpm	feet per gallons per minute
ftp	File Transfer Protocol
gpcpd	gallons per capita per day
GIS	Geographic Information System
GMA	Growth Management Act
Gpd/ft	gallons per day per foot
Gpm/af/yr	gallons per minute per acre-feet per year
Gpm/ft	gallons per minute per foot
HCCC	Hood Canal Coordinating Council
HUC	Hydrologic Units Codes
IFIM	Instream Flow Incremental Methodology
ISFs	Instream Flows
LULC	Land Use and Land Cover

TABLE 1-1

Acronym List

m/s	meters per second
max	maximum
mg/L	milligrams per liter
mi^2	square miles
min	minimum
mL	milliliters
mm/h	millimeters per hour
MSL	Mean Sea Level
NASA	National Aeronautics & Space Administration
NAWQA	National Water-Quality Assessment Program
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NID	National Inventory of Dams
NOAA	National Oceanic and Atmospheric Administration
nr	near
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units
NW	North West
P_{ET}	Potential Evapotranspiration
POD	Point of Diversion
POR	Period of Record
ppb	parts per billion
ppt	Precipitation
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PU	Planning Unit
Qa	Annual Water Use
Qa/Qi	ratio for non-irrigation groundwater and surface water rights
Qi	Instantaneous Water Use
R	Runoff
RCW	Revised Code of Washington
RM	River Mile
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
stn	Station
TMDL	Total Maximum Daily Load
TRS	Township, Range, Section
U of W	University of Washington
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
w/o	without

TABLE 1-1

Acronym List

WA, Wa, Wash.	Washington
WAC	Washington Administrative Code
WMA	Watershed Management Act
WQMP	Water Quality Management Program
WRATS	Water Rights Application Tracking System
WRIA	Water Resource Inventory Area
WRIA 16	Skokomish/Dosewallips WRIA
WRIS	Water Resources Information System

Technical Assessment Requirements of the Watershed Management Act (WMA) Status (from EES,1999)

Component	Technical Assessment Requirements of the Watershed Management Act (WMA)
Water Quantity	An estimate of the surface water and groundwater present in the management area.
	An estimate of the surface water and groundwater available in the management area (taking into account seasonal and other variations).
	An estimate of the water in the management area represented by claims in the claims registry, water use permits, certificated rights, existing minimum instream flow rules, federally reserved rights, and any other rights to water.
	An estimate of the surface water and groundwater actually being used in the management area.
	An estimate of the water needed in the future for use in the management area.
	Identification of the location of areas where aquifers are known to recharge surface water bodies and areas known to provide for the recharge of aquifers from the surface.
	An estimate of the surface water and groundwater available for further appropriation, taking into account the minimum instream flows adopted by rule or to be adopted by rule under this chapter for streams in the management area including the data necessary to evaluate necessary flows for fish.
Water Quality	An examination based on existing studies conducted by federal, state and local agencies of the degree to which legally established water quality standards are being met in the management area.
	An examination based on existing studies conducted by federal, state and local agencies of the causes of water quality violations in the management area, including an examination of information regarding pollutants, point and non-point sources of pollution, and pollution-carrying capacities of water bodies in the management area. the analysis shall take into account seasonal stream flow or level variations, natural events and pollution from natural sources that occurs independent of human activities.
	An examination of the legally established characteristic uses of each of the nonmarine water bodies in the management area.
	An examination of any Total Maximum Daily Load (TMDL) established for nonmarine water bodies in the management area, unless a TMDL process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060.
	An examination of existing data related to the impact of fresh water on marine water quality.
	A recommended approach for implementing the TMDL established for achieving compliance with water quality standards for the nonmarine water bodies in the management area, unless a TMDL process has begun in the management area as of the date the watershed planning process is initiated under RCW 90.82.060.
	Recommended means of monitoring by appropriate government agencies whether actions taken to implement the approach to bring about improvements in water quality are sufficient to achieve compliance with water quality standards.

Kennedy-Goldsborough WRIA 14 Area Summary

Sub-basin	Acres	Miles
Case Inlet	41,638	65.1
Goldsborough	99,389	155.3
Kennedy	34,192	53.4
Skookum	21,276	33.2
WRIA 14*	196,495	307.0

* Less the Hood Canal South Shore

Averages PRISM Precipitation by Sub-basin

Sub-basin/Catchment	Area (Acres)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Case Inlet	41,638	8.6	6.9	6.1	3.5	2.3	1.7	1.0	1.2	2.4	4.9	8.9	9.2	56.7
Lower Goldsborough	73,638	10.2	8.0	6.8	4.1	2.4	1.8	1.0	1.3	2.7	5.5	10.2	10.7	64.6
Lower Kennedy	23,297	9.1	7.0	6.0	3.8	2.3	1.8	0.9	1.3	2.5	5.0	9.2	9.5	58.6
Goldsborough	99,389	10.7	8.3	7.1	4.3	2.5	1.9	1.0	1.3	2.9	5.7	10.6	11.2	67.6
Kennedy	34,192	9.9	7.5	6.5	4.1	2.4	1.9	1.0	1.3	2.7	5.3	9.8	10.3	62.7
Skookum	21,276	10.8	8.1	7.2	4.3	2.5	1.9	1.0	1.3	2.9	5.9	10.4	11.4	67.9
Upper Goldsborough	25,751	12.1	9.4	8.0	4.9	2.8	2.1	1.1	1.4	3.2	6.4	11.9	12.5	75.7
Upper Kennedy	10,895	11.9	8.6	7.7	4.9	2.9	2.3	1.0	1.5	3.2	6.2	11.3	12.6	74.2
WRIA 14	211,252	9.9	7.7	6.7	4.0	2.4	1.8	1.0	1.3	2.7	5.4	9.9	10.4	63.3

Source: Average annual precipitation from PRISM

Average PRISM Temperature by Sub-basin

Sub-basin/Catchment	January	February	March	April	May	June	July	August	September	October	November	December	Average
Case Inlet	4.2	5.7	7.3	9.5	12.7	15.6	17.7	18.0	15.3	10.9	6.9	4.4	10.7
Lower Goldsborough	4.2	5.6	7.2	9.5	12.8	15.7	17.9	18.1	15.4	10.9	6.7	4.3	10.7
Upper Goldsborough	4.0	5.1	7.1	9.4	12.4	15.3	17.5	17.7	15.1	10.7	6.2	3.9	10.4
Skookum	4.0	5.5	7.1	9.4	12.7	15.6	17.8	18.1	15.3	10.8	6.5	4.1	10.6
Lower Kennedy	3.9	5.5	7.1	9.3	12.6	15.5	17.7	18.0	15.2	10.7	6.6	4.1	10.5
Upper Kennedy	3.3	5.0	6.7	9.0	12.1	15.0	17.2	17.5	14.7	10.4	5.8	3.5	10.0
Upper Mason	4.2	5.6	7.3	9.6	12.7	15.6	17.7	17.9	15.3	11.0	6.7	4.3	10.6
WRIA 14	4.1	5.5	7.2	9.5	12.7	15.5	17.7	18.0	15.3	10.8	6.6	4.2	10.6

Table 4-x
Average Temperature (^{o}F)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Case Inlet	39.5	42.2	45.1	49.1	54.9	60.0	63.9	64.3	59.6	51.7	44.4	39.9	51.2
Lower Goldsborough	39.5	42.0	45.0	49.2	55.0	60.2	64.1	64.6	59.7	51.6	44.1	39.7	51.2
Upper Goldsborough	39.2	41.2	44.7	48.9	54.4	59.6	63.5	63.9	59.2	51.3	43.2	39.1	50.7
Skookum	39.2	41.9	44.8	49.0	54.8	60.0	64.0	64.5	59.5	51.4	43.7	39.4	51.0
Lower Kennedy	39.1	42.0	44.7	48.7	54.6	59.9	63.9	64.4	59.3	51.2	43.8	39.3	50.9
Upper Kennedy	38.0	40.9	44.0	48.1	53.8	58.9	63.0	63.5	58.5	50.6	42.5	38.2	50.0
Upper Mason	39.5	42.0	45.1	49.3	54.8	60.0	63.9	64.3	59.6	51.7	44.1	39.7	51.2
WRIA 14	39.3	41.9	44.9	49.0	54.8	60.0	63.9	64.4	59.5	51.5	43.9	39.5	51.0

Population Growth 1990-2000

Sub-Area	Sub-Area Area ($mile^2$)	1990 Population	2000 Population	Population Increase	1990-2000 Growth	1990-2000 Annual Growth Rate	1990 Pop. Density ($people/mile^2$)	2000 Pop. Density ($people/mile^2$)	Change in Pop. Density ($people/mile^2$)
Case	65.1	4,165	5,132	967	23%	2.1%	64	79	15
Goldsborough	155.3	19,066	24,663	5,597	29%	2.6%	123	159	36
Kennedy	53.4	4,853	6,307	1,454	30%	2.7%	91	118	27
Skookum	33.2	2,295	3,285	990	43%	3.7%	69	99	30
TOTAL	**307.0**	**30,379**	**39,387**	**9,008**	**30%**	**2.6%**	**99**	**128**	**29**

Note: Sub-basin areas include only non marine acres.

Projected Population 2000-2010

Sub-Area	Sub-Area Area ($mile^2$)	2000 Population	2000 Population Density ($people/mile^2$)	2000-2010 Projected Annual Growth Rate	Projected 2010 Population	Increase in Population	Projected 2010 Population Density ($people/mile^2$)	Change in Pop. Density 2000-2010 ($people/mile^2$)
Case Inlet	65	5,132	79	2.1%	6,324	1,192	97	18
Goldsborough	115	24,663	159	2.6%	31,903	7,240	277	118
Kennedy	53	6,307	118	2.7%	8,197	1,890	153	35
Skookum	33	3,285	99	3.7%	4,702	1,417	141	43
TOTAL	**267**	**39,387**	**128**	**2.6%**	**51,066**	**11,739**	**191**	**63**

Note: Sub-basin areas include only non marine acres.

Station Summeries for USGS Gaging Stations in WRIA 14

USGS Sation #	Station Name	First Gauging	Last Gauging	Lat	Long	Elevation (MSL ft) (NGVD29)	Drainage Area (mi2)	Station Status	Continous Years of Record	Mean Annual Flow (cfs)
12075000	Deer Creek Near Shelton, WA	1/1/43	9/30/51	471600	1230015		13.6	Inactive	2.0	45
12075500	Cranberry Creek Near Shelton, WA	1/1/43	9/30/51	471600	1230030		15.2	Inactive	3.0	50.8
12076000	Johns Creek Near Shelton, WA	1/1/43	9/30/51	471500	1230515		17.7	Inactive	2.0	27.4
12076500	Goldsborough Creek Near Shelton, WA	7/1/51	9/30/71	471256	1231052	205	39.9	Inactive	20.0	115.2
12077000	Goldsborough Creek At Shelton, WA	1/1/43	9/30/51	471230	1230600		55	Inactive	0.0	Peak Only
12077500	Mill Creek At Shelton, WA	1/1/43	9/30/51	471145	1230545		19.5	Inactive	0.0	Peak Only
12078000	Skookum Creek At Kamilche, Wash.	7/1/51	10/31/58	470730	1230650	35	16.1	Inactive	7.0	54.6
12078400	Kennedy Creek Near Kamilche, WA	2/1/60	9/30/71	470437	1230733	110	17.4	Inactive	11.0	60.6
12078600	Schneider Creek Tributary Near Shelton, WA	12/28/49	2/11/69	470525	1230430		1.12	Inactive	19.1	Peak Only

Empirical Annual Water Balance Summary

Sub-basin	Acreage	Precipitation[1]	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
Case	41,638	196,815	74,038	53,433	69,344	16,684	52,660	0	70,117	0
Goldsborough	99,389	559,530	172,474	183,279	203,778	53,563	150,215	0	236,842	0
Kennedy	34,192	178,543	60,186	79,041	39,316	14,369	24,947	0	93,410	0
Skookum	21,276	120,310	37,167	49,641	33,501	10,785	22,716	0	60,427	0
Upper Goldsborough	25,751	162,355	41,643	58,114	46,080	16,518	46,080	0	74,632	0
Upper Kennedy	10,895	67,327	19,742	41,748	3,136	2,701	3,136	0	44,449	0
Upper Mason	14,757	74,289	26,043	20,997	27,249	6,556	20,693	0	27,553	0
WRIA 14	**211,252**	**1,359,170**	**431,293**	**486,251**	**422,405**	**121,177**	**320,448**	**0**	**607,429**	**0**

Water Balance Summary Normalized to a Unit Acre

Sub-basin	Acreage	Precipitation[1]	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Streamflow[8]
Case	41,638	4.73	1.78	1.28	1.67	0.40	1.26	1.68
Goldsborough	99,389	5.63	1.74	1.84	2.05	0.54	1.51	2.38
Kennedy	34,192	5.22	1.76	2.31	1.15	0.42	0.73	2.73
Skookum	21,276	5.65	1.75	2.33	1.57	0.51	1.07	2.84
Upper Goldsborough	25,751	6.30	1.62	2.26	1.79	0.64	1.79	2.90
Upper Kennedy	10,895	6.18	1.81	3.83	0.29	0.25	0.29	4.08
Upper Mason	14,757	5.03	1.76	1.42	1.85	0.44	1.40	1.87

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Method and a soil moisture holding capacity of 6 inches
3) Runoff calculated as a percent of annual availible water based on the percentage of basalt covering the sub-basin and distributed among the months.
4) Groundwater Residual = Precipitation-Actual Evapotranspiration-Runoff
5) Baseflow is calculated as a percentage of groundwater residual plus baseflow based on the percentage of basalt covering the sub-basin and distributed among the months.
6) Monthly underflow = (annual groundwater residual - baseflow)/12
7) Change in groundwater storage = groundwater residual - baseflow - underflow
8) Streamflow = runoff+ baseflow
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.

Summary of Water Rights Documents

Purpose of Use	Application	Certificate	Change/ Application	Claim/[a]	Claim/L	Claim/S	Permit	Total	Percent
Municipal		3					1	4	0%
Irrigation	10	255		1	344	479	3	1,092	25%
Domestic	70	647			1,384	970	71	3,142	72%
Commercial-Industrial	7	26						33	1%
Other Uses[b]	1	11	12	1	37	18		80	2%
Non-Consumptive[c]	3	12					1	16	0%
Total	91	954	12	2	1,765	1,467	76	4,367	100%
Percent	2%	22%	0%	0%	40%	34%	2%	100%	

Notes:

a. Claims filed during last claim registration period (September 1, 1997 through June 30, 1998).

b. Other uses include recreation,mining, and stock. Changes and some claims do not have a purpose of use listed and are included as other.

c. Non-consumptive use includes power, fish, and fire.

d. Data source: Washington State Department of Ecology, "WRATS (Water Rights Applications Tracking System) on a Bun" , August 2001

Summary of Certificate and Permit Analysis

	Groundwater Certificates and Permits					Surface Water Certificates and Permits				
	Purpose of Use					Purpose of Use				
	MU	IR	D*	CI	Other	MU	IR	D*	CI	Other
Number of Documents	3	72	241	17	2	1	186	477	9	11
Percent without Qa	-	1%	4%	-	-	100%	42%	22%	100%	91%
Mean Qa (AF/yr)	1,345	32	0.17	2.56	127	-	20	0.76	-	-
Median Qa (AF/yr)	1,344	9	0.11	0.33	127	-	4	0.34	-	-
Mean Qi/Qa (cfs/AF/yr)	0.01	0.01	0.02	0.02	0.01	-	0.02	0.04	-	-
Median Qi/Qa (cfs/AF/yr)	0.01	0.01	0.01	0.003	0.006	-	0.01	0.04	-	-
Mean Irrigated Acres	-	11	-	-	-	-	14.9	-	-	-
Median Irrigated Acres	-	4	-	-	-	-	4.0	-	-	-
Mean Duty (ft)	-	3.0	-	-	-	-	2.0	-	-	-
Median Duty (ft)	-	2.5	-	-	-	-	2.0	-	-	-

Note:
Purpose of use: MU - municipal, IR - irrigation, D* - domestic, CI -commercial-industrial, Other - includes mining, stock, recreation.
Data source: Washington State Department of Ecology, "WRATS (Water Rights Applications Tracking System) on a Bun" , August 2001.

Summary of Allocations by Document Type

	Subbasin					
	Case Inlet	**Goldsborough**	**Kennedy**	**Skookum**	**Total**	**Percent**
Groundwater						
Application	-	-	-	-	-	
Change Application	-	-	-	-	-	
Certificates	3,972	25,759	1,357	858	31,946	82%
Claim/	0	0	22	0	22	0%
Claim/L	1,111	1,038	1,108	368	3,624	9%
Claim/S	151	295	78	83	606	2%
Permit	448	1,885	56	194	2,582	7%
Subtotal (acre-feet/year)	5,681	28,977	2,619	1,502	38,780	100%
Percent	15%	75%	7%	4%	100%	
Surface Water						
Application	-	-	-	-	-	
Change Application	-	-	-	-	-	
Certificates	376	26,028	913	767	28,084	93%
Claim/		60	0	0	60	0.2%
Claim/L	207	660	168	169	1,203	4%
Claim/S	36	54	37	9	135	0.4%
Permit		560	21	0	581	2%
Subtotal (acre-feet/year)	619	27,361	1,139	944	30,063	100%
Percent	2%	91%	4%	3%	100%	
TOTAL (acre-feet/yr)	**6,301**	**56,338**	**3,758**	**2,446**	**68,842**	
PERCENT	**9%**	**82%**	**5%**	**4%**	**100%**	

	Subbasin					
	Case Inlet	**Goldsborough**	**Kennedy**	**Skookum**	**Total**	
Groundwater						
Application	19	26	8	7	60	2%
Change Application	2	5	1	0	8	0%
Certificates	96	112	90	30	328	11%
Claim/	0	0	1	0	1	0%
Claim/L	439	528	368	145	1,480	48%
Claim/S	302	590	155	165	1,212	39%
Permit	3	7	1	4	15	0%
Subtotal (number of documents)	861	1,268	624	351	3,104	100%
Percent	28%	41%	20%	11%	100%	
Surface Water						
Application	2	2	21	1	26	2%
Change Application	1	2	1	0	4	0%
Certificates	76	210	297	36	619	49%
Claim/	0	1	0	0	1	0%
Claim/L	90	82	93	15	280	22%
Claim/S	72	107	73	17	269	21%
Permit	0	2	56	0	58	5%
Subtotal (number of documents)	241	406	541	69	1,257	100%
Percent	19%	32%	43%	5%	100%	
TOTAL (number of documents)	**1,102**	**1,674**	**1,165**	**420**	**4,361**	
PERCENT	**25%**	**38%**	**27%**	**10%**	**100%**	

Summary of Allocations by Purpose of Use

	Subbasin					
	Case	Goldsborough	Kennedy	Skookum	Total	Percent
Groundwater						
Municipal	0	4,034	0	0	4,034	10%
Irrigation	2,420	1,180	1,228	535	5,363	14%
Domestic	3,242	4,173	1,355	927	9,697	25%
Commercial-Industrial	17	19,327	34	37	19,415	50%
Other	3	263	3	3	271	1%
Subtotal (acre-feet/year)	5,681	28,977	2,619	1,502	38,780	100%
Percent	15%	75%	7%	4%	100%	
Surface Water						
Municipal	0	504	0	0	504	2%
Irrigation	376	3,229	824	899	5,328	18%
Domestic	102	138	303	35	579	2%
Commercial-Industrial	36	22,200	0	0	22,236	74%
Other	105	1,290	12	10	1,417	5%
Subtotal (acre-feet/year)	619	27,361	1,139	944	30,063	100%
Percent	2%	91%	4%	3%	100%	
TOTAL (acre-feet/yr)	**6,301**	**56,338**	**3,758**	**2,446**	**68,842**	
PERCENT	**9%**	**82%**	**5%**	**4%**		
Groundwater						
Municipal	0	3	0	0	3	0.1%
Irrigation	181	358	109	97	745	24%
Domestic	669	873	507	246	2,295	74%
Commercial-Industrial	2	9	2	3	16	0.5%
Other	9	25	6	5	45	1%
Subtotal (number of documents)	861	1,268	624	351	3,104	100%
Percent	28%	41%	20%	11%	100%	
Surface Water						
Municipal	0	1	0	0	1	0.1%
Irrigation	61	210	49	27	347	28%
Domestic	173	172	484	39	868	69%
Commercial-Industrial	2	4	0	0	6	0.5%
Other	5	19	8	3	35	3%
Subtotal (number of documents)	241	406	541	69	1,257	100%
Percent	19%	32%	43%	5%	100%	
TOTAL (number of documents)	**1,102**	**1,674**	**1,165**	**420**	**4,361**	
PERCENT	**25%**	**38%**	**27%**	**10%**	**100%**	

Note:
Other includes mining, stock, recreation, etc.
Change applications do not have a purpose of use listed and are included as other.

Pending Water Right Applications

Name	Purpose of Use	Instantaneous Quantity	TRS	Priority Date	Water Right Number
CASE SUB-BASIN					
Applications for New Water Rights - Groundwater					
		(gpm)			
ANDERSON & SONS INC,	IR DM	600	T22N/R01W-20	02-Oct-92	G2-28625
ANDERSON, MARK	DM	300	T20N/R02W-10	24-Aug-93	G2-28929
DAWNVIEW CREST HOMEO	DM	40	T20N/R02W-28	24-Jan-94	G2-28999
VINDING, VERLE	DM	30	T21N/R02W-12	28-Sep-94	G2-29119
FARREN, MICHAEL	DM	40	T21N/R01W-07	07-Dec-94	G2-29159
MASON CNTY PUD 1,	DM	340	T22N/R03W-32	03-Nov-95	G2-29315
GUTTORMSEN BROS,	DM	50	T22N/R01W-29	09-Sep-96	G2-29415
WASHINGTON WATER SER	DM	100	T22N/R01W-20	13-Feb-97	G2-29463
PICKERING PASSAGE WA	DM	37	T21N/R01W-18	23-Jan-98	G2-29586
MASON CNTY PUD 1,	DM	35	T20N/R02W-03	02-Sep-98	G2-29782
JURGES, GLEN	DM	115	T21N/R01W-05	12-Mar-02	G2-30046
Applications for New Water Rights - Surface Water					
		(cfs)			
SVENDSEN, FERN	CI	0.02	T22N/R01W-30	16-Sep-96	S2-29416
LAAKSO, ROBERTA	DS	0.03	T22N/R03W-34	09-Sep-97	S2-29518
KENNEDY					
Applications for New Water Rights - Groundwater					
		(gpm)			
GRIFFIN SCHOOL DIST	IR DM	40	T18N/R03W-02	27-Jan-94	G2-28993
DAWNVIEW CREST HOMEO	DM	40	T20N/R02W-28	24-Jan-94	G2-28999
MASTEY-ODEGAARD,	DM	200	T19N/R02W-04	05-May-94	G2-29046
MAKOVINEY, ED	DM CI	90	T18N/R03W-02	16-Jan-96	G2-29340
BURNS POINT BEACH WA	DM	30	T19N/R03W-27	06-Jan-99	G2-29823
GRIFFIN SCHOOL DISTR	IR DM	60	T19N/R03W-35	27-Nov-00	G2-29960
Applications for New Water Rights - Surface Water					
		(cfs)			
ARNOLD, KIM	DS	0.02	T18N/R03W-17	12-Apr-95	S2-29228
DOUGHERTY, KRISTA	DS	0.02	T18N/R03W-07	06-Mar-98	S2-29601
UNDERLAND, ROBERT	DS	0.02	T18N/R03W-08	04-Jun-98	S2-29694
UNDERLAND, ROBERT	DS	0.02	T18N/R03W-08	04-Jun-98	S2-29695
BATES, DAN	DS	0.01	T18N/R03W-18	09-Mar-00	S2-29904
BESTE, LAWRENCE	DS	0.02	T18N/R03W-08	10-Aug-00	S2-29931
KRAMER, SCOTT	DS	0.02	T18N/R03W-18	11-Sep-00	S2-29936
MAXIN, PAUL	DS	0.02	T18N/R03W-08	22-Sep-00	S2-29941
HAYMON, JAMES	DS	0.02	T18N/R03W-08	15-Sep-00	S2-29942
HAYMON, JAMES	DS	0.02	T18N/R03W-08	15-Sep-00	S2-29943
HAYMON, JAMES	DS	0.02	T18N/R03W-08	15-Sep-00	S2-29944
HAYMON, JAMES	DS	0.02	T18N/R03W-08	15-Sep-00	S2-29945
MITCHELL, HAROLD	DS	0.02	T18N/R03W-07	21-Sep-00	S2-29947
THOMPSON, ALTA	DS	0.02	T18N/R03W-07	10-Oct-00	S2-29949
COBURN, HARVEY	DS	0.01	T18N/R03W-08	25-Oct-00	S2-29957
TEAL, RICHARD	DS	0.02	T18N/R03W-08	07-Sep-01	S2-30015
MUSSER, ROGER	DS	2	T18N/R03W-08	06-Apr-01	S2-30016
MUSSER, ROGER	DS	0.02	T18N/R03W-08	06-Sep-01	S2-30017
BESTE, MICHEAL	DS	0.02	T18N/R03W-08	14-Sep-01	S2-30020
OLSON, JAMES	DS	0.02	T18N/R03W-08	19-Nov-01	S2-30033
COLLINS, CHARLES	DS	0.02	T18N/R03W-08	15-Mar-02	S2-30047
Change Applications - Groundwater					
MAPLE SHORES COMMUNI		60	T19N/R02W-20	25-Mar-99	CG2-25317
Change Applications - Surface Water					
SHAFFER, MARK		0.02	T18N/R03W-08	18-Jun-01	CS2-29691

Pending Water Right Applications

Name	Purpose of Use	Instantaneous Quantity	TRS	Priority Date	Water Right Number
GOLDSBOROUGH					
Applications for New Water Rights - Groundwater					
		(gpm)			
FRIEND, JOHN	DM	100	T20N/R03W-15	28-Apr-92	G2-28484
FULLER, KEITH	DM	50	T21N/R04W-25	19-May-92	G2-28494
SHELTON PORT,	CI	300	T20N/R04W-02	18-May-92	G2-28520
SHELTON PORT,	IR CI	85	T20N/R03W-04	18-May-92	G2-28544
SHELTON PORT,	IR CI	240	T20N/R03W-09	18-May-92	G2-28545
BUNKO, NORMAN & BERN	DS	15	T20N/R03W-27	18-Dec-92	G2-28698
NEAL, WILLIAM	DM	100	T21N/R02W-16	09-Mar-93	G2-28796
ALPINE EVERGREEN CO	DM	200	T20N/R03W-06	09-Sep-93	G2-28930
DUMONTET, DONALD	CI	19	T20N/R04W-17	10-Nov-93	G2-28959
MANKE LUMBER CO,	DM	25	T20N/R03W-28	13-Dec-93	G2-28973
PARRETT, RICHARD	DM	40	T20N/R03W-24	12-Nov-93	G2-28994
DRAKE, HERMAN	DM	175	T21N/R04W-25	19-Jan-94	G2-28996
DRAKE, HERMAN	DM	150	T21N/R04W-25	21-Jan-94	G2-29008
JENSEN, MARTIN	DM	45	T20N/R02W-21	22-Feb-94	G2-29011
STOREYBROOK HOMEOWNE	DM	50	T20N/R03W-31	27-Jun-94	G2-29096
HOFERT FAMILY TRUST,	DM	110	T21N/R04W-35	21-Aug-95	G2-29266
CATFISH LAKE COMMUNI	RE	100	T21N/R03W-34	20-Sep-95	G2-29288
WA DEPARTMENT OF COR	DM	660	T20N/R04W-09	13-May-96	G2-29387
LAKE LIMERICK COUNTR	DM	210	T21N/R03W-27	24-Apr-97	G2-29483
O'DAY, GEORGE	IR	50	T21N/R03W-36	16-May-97	G2-29488
HOAM WATER SYSTEM,	DM	40	T20N/R03W-26	05-Dec-97	G2-29555
WASHINGTON WATER SER	DM	50	T20N/R03W-10	15-May-98	G2-29650
LILES, JERRY	IR DS	50	T21N/R03W-36	28-May-98	G2-29665
SPENCER GLEN HOMEOWN	DM	30	T21N/R02W-32	19-Jun-98	G2-29667
BAYSHORE INC,	DM	260	T20N/R03W-03	29-Oct-98	G2-29818
BOWMAN, LEE	IR DS	30	T19N/R04W-05	27-Jun-00	G2-29922
Applications for New Water Rights - Surface Water					
		(cfs)			
MCMURPHY, DELORES	DS	0.01	T19N/R04W-03	06-Sep-94	S2-29112
TOBIN, TYLER	FS	0.2	T20N/R04W-08	04-Sep-96	S2-29418
DEFILIPPS, VINCE	DS	0.01	T20N/R05W-25	08-May-00	S2-29913
Change Applications - Groundwater					
WA D O I/WASHINGTON		1126	T20N/R04W-09	23-Oct-97	CG2-*07086
OAK PARK WATER CO,		210	T20N/R03W-06	04-Aug-97	CG2-01135
OAK PARK WATER CO,		500	T20N/R03W-06	04-Aug-97	CG2-27879
FOX, MICHAEL		50	T20N/R04W-22	24-Sep-96	CG2-28357
SALMON, GERALD			T20N/R02W-20	25-Apr-02	CG2-39465CL
Change Applications - Surface Water					
BAYSHORE INC,		2.56	T20N/R03W-03	27-Jun-99	CS2-*01937
HEINOLD & DEFFINBAUG		0.05	T21N/R02W-32	27-Apr-01	CS2-*12569
SKOOKUM					
Applications for New Water Rights - Groundwater					
		(gpm)			
EVERGREEN LAND & WAT	DM	75	T19N/R03W-05	21-Apr-92	G2-28462
GRIMES, RICHARD	IR DS	37.5	T19N/R03W-04	06-Jul-93	G2-28894
DELSON LUMBER CO,	FP	120	T19N/R04W-24	28-Sep-93	G2-28940
TAYLOR UNITED INC,	CI	280	T19N/R03W-17	06-Dec-93	G2-28988
DAWNVIEW CREST HOMEO	DM	40	T20N/R02W-28	24-Jan-94	G2-28999
JENSEN, MARTIN	DM	45	T20N/R02W-21	22-Feb-94	G2-29011
WASHINGTON WATER SER	DM	160	T19N/R03W-04	07-Jul-94	G2-29072
SQUAXIN ISLAND TRIBE	DM	100	T19N/R03W-18	06-Jun-00	G2-29918
Applications for New Water Rights - Surface Water					
		(cfs)			
KAUFMAN, MARJORIE	DS	0.02	T19N/R03W-08	03-Aug-00	S2-29928

Stream Closures and Flow Limitations

Stream Name	Tributary to	Closure Period Under WAC 173-514 (as of 1/23/84)	Closure or Flow Limitation Date Under RCW 75.20	MISF Established
Alderbrook Creek	Hood Canal	May 1 - October 31	-	No
Campbell Creek	Oakland Bay	May 1 - October 31	-	No
Cranberry Creek		September 16 - November 15	-	Yes
Deer Creek		September 16 - November 15	-	Yes
Elson Creek	Skookum Inlet	May 1 - October 31	-	No
Fawn Lake Outlet	Skookum Inlet	May 1 - October 31	-	No
Goldsborough Creek	Oakland Bay	May 1 - October 31	4/14/54	Yes
Gosnell Creek	Isabella Lake	All year	12/4/61	10 cfs
Jarrell Creek	Jarrell Cove	May 1 - October 31	7/7/59	No
Johns Creek	Oakland Bay	September 16 - November 15	7/7/59	Yes
Jones Creek	Pickering Passage	May 1 - October 31	-	No
Kennedy Creek	Totten Inlet	May 1 - November 15	10/15/53	Yes
Little Creek	Skookum Creek	May 1 - October 31	-	No
Melaney Creek	Oakland Bay	May 1 - October 31	-	No
Mill Creek	Isabella Lake	N/A	Yes	Yes
Perry Creek		May 1 - October 31	-	Yes
Schneider Creek	Totten Inlet	May 1 - October 31	5/4/53	No
Shelton Creek	Oakland Bay	May 1 - October 31	-	No
Sherwood Creek		September 16 - November 15	-	Yes
Shumocher Creek		N/A	-	Yes
Skookum Creek	Skookum Inlet	May 1 - October 31	6/25/75	Yes
Summit Lake	Kennedy Creek	All year	11/29/54	N/A (Lake Level)
Twahnoh Creek	Hood Canal	May 1 - October 31	-	No
Uncle John Creek	Oakland Bay	May 1 - October 31	-	No
Unnamed Stream (Sec.34, T.20N-R.3 EWM)	Mill Creek	All year	2/11/53	2 cfs

Source: WAC 173-514-040 Surface water source limitations to further

Public Water Systems (PWS)

Sub-Basin	Group A		Group B		Total	
	Community PWS	Residential Population	PWS	Residential Population	PWS	Residential Population
Case Inlet	27	6,536	173	1,827	200	8,363
Goldsborough	30	17,251	179	1,745	209	18,996
Kennedy	13	2,313	49	516	62	2,829
Skookum	7	1,384	38	348	45	1,732
Totals	**77**	**27,484**	**439**	**4,436**	**516**	**31,920**

TABLE 8-2

1990 and 2000 Census Data

	1990 Census	2000 Census
Sub-Basin		
Case Inlet	4,165	5,132
Goldsborough	19,066	24,663
Kennedy	4,853	6,307
Skookum	2,295	3,285
Totals	**30,379**	**39,387**
Counties		
Mason	25,792	33,478
Thurston	4,603	5,932

Note: Small discrepancies in population totals are an artifact of GIS manipulation.
Data source: 1990 and 2000 US census

PWS and Exempt Well Population

Sub-Basin	2000 Census Data Population	Total Residential Population Served by PWS	Residential Population on Exempt Wells
Case Inlet	5,132	8,363	NA
Goldsborough	24,663	18,996	5,667
Kennedy	6,307	2,829	3,478
Skookum	3,285	1,732	1,553
Totals	**39,387**	**31,920**	**10,698**

*Residential population served by PWS greater than 2000 Census data.

Current 2000 Public Water Systems (PWS) and Exempt Well Water Use

Sub-Basin	Sub-Basin Area ($mile^2$)	2000 Population	Per Capita Water Use (gallons/yr)*	Per Capita per Year Water Use (AF/yr)	Residential Population on PWS	PWS Water Use (AF/yr)	Exempt Well Population**	Exempt Well Water Use (AF/yr)	Total Water Use (AF/yr)	Total Water Use Population Based (AF/yr)
Case Inlet	119.5	5,132	43,800	0.13	8,363	1,087	NA	NA	1,087	667
Kennedy	65.5	6,307	43,800	0.13	2,829	368	3,478	452	820	820
Goldsborough	160.0	15,601 ***	43,800	0.13	9,934	1,291	5,667	737	2,028	2,028
Skookum	36.6	3,285	43,800	0.13	1,732	225	1,553	202	427	427
City of Shelton service area		9,062	68,620	0.21	9,062	1,903	NA	NA	1,903	1,903
Totals	**381.6**	**39,387**			**31,920**	**4,875**	**10,698**	**1,391**	**6,265**	**5,845**

*Assumes no conservation. Per capita water use was assumed at 120 gpcd for sub-basins and 188 gpcd for City of Shelton service area.

**Refer to Chapter 8 of the text for discussion related to entry for population on exempt wells is NA, it was assumed that the total population is on purveyor systems, for these sub-basins.

***Subbasin population minus City of Shelton service area.

Non-community Public Water Systems (PWS)

Sub-Basin	Non-community Systems	Non-community Connections	Water use per connection (gal/yr)*	Water use per connection (AF/yr)	Total water use (AF/yr)
Case Inlet	26	571	56,940	0.175	100
Goldsborough	24	237	56,940	0.175	41
Kennedy	11	91	56,940	0.175	16
Skookum	6	45	56,940	0.175	8
Totals	67	944			165

* based on water use per connection of half of community connections, or 156 gal/day.

Projected 2010 Residential and Municipal Water Use

Sub-Basin	1990 Census	2000 Census	Increase/ Decrease	10-year Percent Increase	Projected 2010 Population***	Projected Per Capital Water Use (gal/yr)	Per Capita Water Use (AF/yr)	Total Water Use (AF/yr)
Case Inlet	4,165	5,132	967	23.2%	6,323	43,800	0.13	822
Goldsborough	12,060	15,601 **	3541	29.4%	20,188	43,800	0.13	2,624
Kennedy	4,853	6,307	1454	30.0%	8,199	43,800	0.13	1,066
Skookum	2,295	3,285	990	43.1%	4,698	43,800	0.13	611
City of Shelton service area*		9,062			12,632	68,620	0.21	2,653
Total	**23,373**	**30,325**	**6,952**	**29.7%**	**51,134**			**7,776**

* From City of Shelton 2001 Water System Plan.
**Sub-basin population minus City of Shelton service area.
***Based on same percent increase in subbasin populations as 10-year period from 1990 - 2000.

Water Quality Standards for Freshwater (WAC 173-201A)

Parameter	Class AA	Class A	Class B	Lake Class
Fecal Coliform	Geometric mean <50 colonies /100 mL and <10% of samples >100 colonies/100 mL	Geometric mean <100 colonies /100 mL and <10% samples >200 colonies/100 mL	Geometric mean <200 colonies /100 mL and <10% samples >400 colonies/100 mL	Geometric mean <50 colonies /100 mL and <10% of samples >100 colonies/100 mL
Dissolved Oxygen	>9.5 mg/L	>8.0 mg/L	>6.5mg/L	No measurable change from natural condition
Total Dissolved Gas	<110% of saturation	<110% of saturation	<110% of saturation	<110% of saturation
Temperature	<16.0 C or if > 16 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=23/(T+5), Non-point source activities shall not exceed 2.8 C	<18.0 C or, if >18 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=28/(T+7), Non-point source activities shall not exceed 2.8 C	<21.0 C or, if >21 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=34/(T+9), Non-point source activities shall not exceed 2.8 C	No measurable change from natural condition
pH	6.5 - 8.5 with a human-caused variation of <0.2 within the range	6.5 - 8.5 with human-caused variation of <0.5 within the range	6.5 - 8.5 with human-caused variation of <0.5 within the range	No measurable change from natural condition
Turbidity	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU	<10 NTU over background (50 NTU or less) or <20% increase when background is >50 NTU	<5 NTU over background
Toxic, radioactive, or deleterious material	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota or public health
Aesthetic values	No impairment that offends sight, smell, touch, or taste	No impairment that offends sight, smell, touch, or taste	Not reduced by dissolved, suspended, floating or submerged matter, not attributed to natural causes, so as to affect water use or taint the flesh of edible species.	No impairment that offends sight, smell, touch, or taste

t = maximum permissible temperature increase measured at a mixing zone boundary.
T = background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

* Detailed criteria for toxic and radioactive material is presented in WAC 173-201A-040.

TABLE 9-2

Water Quality Standards for Marine Water (WAC 173-201A)

Parameter	Class AA	Class A	Class B
Fecal Coliform	Geo. Mean <14 colonies/100 mL and <10% of samples >43 colonies/100 mL	Geo. Mean <14 colonies/100 mL and <10% of samples >43 colonies/100mL	Geo. Mean <100 colonies/100 mL and <10% of samples >200 colonies/100mL
Dissolved Oxygen	>7.0 mg/L or, if <7 mg/L due to natural conditions, then human-caused degradation must be <0.2 mg/L	>6.0 mg/L or, if <6 mg/L due to natural conditions, then human-caused degradation must be <0.2 mg/L	>5.0 mg/L or, if <5 mg/L due to natural conditions, then human-caused degradation must be <0.2 mg/L
Total Dissolved Gas	<110% of saturation	<110% of saturation	<110% of saturation
Temperature	<13.0 C or, if >13 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=8/(T-4), Non-point source activities shall not exceed 2.8 C	<16.0 C or, if >16 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=12/(T-2), Non-point source activities shall not exceed 2.8 C	<19.0 C or, if >19 C due to natural conditions, no human-caused increases of 0.3 C. Point source activities shall not exceed t=16 /(T), Non-point source activities shall not exceed 2.8 C
pH	7.0 - 8.5 with a human-caused variation of <0.2 within the range	7.0 - 8.5 with human-caused variation of <0.5 within the range	7.0 - 8.5 with human-caused variation of <0.5 within the range
Turbidity	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU	<5 NTU over background (50 NTU or less) or <10% increase when background is >50 NTU	<10 NTU over background (50 NTU or less) or <20% increase when background is >50 NTU
Toxic, radioactive, or deleterious material*	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota, or public health	Below levels which adversely affect characteristic water uses, biota, or public health
Aesthetic values	No impairment that offends sight, smell, touch, or taste	No impairment that offends sight, smell, touch or taste	Not reduced by dissolved, suspended, floating, or submerged matter, not attributed to natural causes, so as to affect water use or taint the flesh of edible

t = maximum permissible temperature increase measured at a mixing zone boundary.

T = background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

* Detailed criteria for toxic and radioactive material is presented in WAC 173-201A-040.

List of Impaired or Threatened Waterbodies (303(d) list)

WRIA	Waterbody Name	Parameter	Township	Range	Section	Latitude	Longitude	New ID #	Old ID #
14	Burns Creek	Fecal Coliform	19N	03W	27			No-ID	WA-14-1195
14	Burns Creek	pH	19N	03W	27			No-ID	WA-14-1195
14	Campbell Creek	Fecal Coliform	20N	03W	13			BH46CN	WA-14-1850
14	Campbell Creek	Fecal Coliform	20N	03W	14			BH46CN	WA-14-1850
14	Case Inlet/Dana Passage	Dissolved Oxygen				47.265	122.845	390KRD	WA-PS-0090
14	Case Inlet/Dana Passage	Fecal Coliform				47.365	122.815	390KRD	WA-PS-0090
14	Case Inlet/Dana Passage	Fecal Coliform				47.395	122.825	390KRD	WA-PS-0090
14	Goldsborough Creek	Fecal Coliform	20N	03W	20			MI94TV	WA-14-1600
14	Hammersley Inlet	Fecal Coliform				47.195	122.995	390KRD	WA-14-0100
14	Kennedy Creek	pH	19N	03W	32			AO33HF	WA-14-1300
14	Oakland Bay	Fecal Coliform				47.205	123.055	390KRD	WA-14-0110
14	Oakland Bay	Fecal Coliform				47.205	123.075	390KRD	WA-14-0110
14	Oakland Bay	Fecal Coliform				47.215	123.065	390KRD	WA-14-0110
14	Oakland Bay	Fecal Coliform				47.225	123.045	390KRD	WA-14-0110
14	Oakland Bay	Fecal Coliform				47.225	123.065	390KRD	WA-14-0110
14	Perry Creek	pH	18N	03W	13			FE29VY	WA-14-1100
14	Pierre Creek	Fecal Coliform	19N	03W	27			No-ID	WA-14-1190
14	Pierre Creek	pH	19N	03W	27			No-ID	WA-14-1190
14	Schneider Creek	pH	19N	03W	33			ER21HD	WA-14-1200
14	Shelton Creek	Fecal Coliform	20N	03W	20			JZ99VQ	WA-14-1650
14	Shelton Harbor (Inner)	Fecal Coliform				47.205	123.095	390KRD	WA-14-0050
14	Skookum Creek	Fecal Coliform	19N	03W	19			BI64LF	WA-14-1400
14	Uncle John Creek	Fecal Coliform	20N	03W	14			No-ID	WA-14-1800

Effects of pH Range on Aquatic Species

pH	Effects on Aquatic Species
3.0 - 3.5	Unlikely that fish can survive for more than a few hours
3.5 - 4.0	Known to be lethal to all salmonid
4.0 - 4.5	All fish, most frogs and insects not present
4.5 - 5.0	Most fish eggs won't hatch; mayfly and other insect species not found
5.0 - 5.5	Bottom dwelling decomposing bacteria begin to die off; plankton begin to disappear
6.0 - 6.5	Freshwater shrimp not present
6.5 - 8.5	Optimal for most organisms
8.5 - 9.0	Unlikely to be harmful to fish, but indirect effects from chemical changes to water may occur
9.0 - 10.5	Harmful to perch and salmonids if prolonged exposure
10.5 - 11.0	Prolonged exposure lethal to carp and perch
11.0 - 11.5	Lethal to all fish species

North Carolina State University 1998

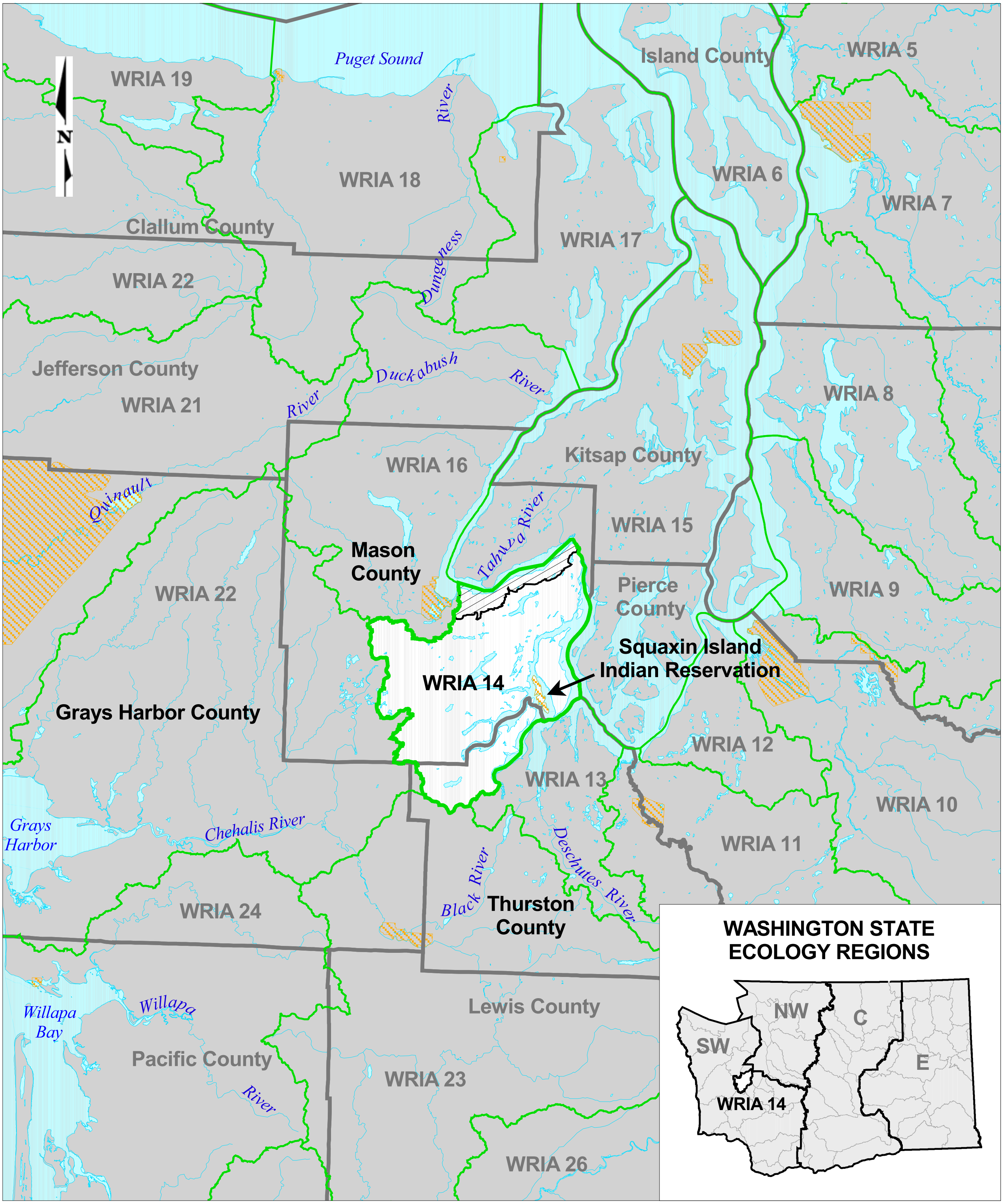
TABLE 10-1

Relative Degree of Allocation and Actual Use

	Case	Goldsborough	Skookum	Kennedy
Water Allocation and Use Estimates (AF/yr)				
Groundwater Allocation	5,682	28,977	1,502	2,619
SW Allocation	619	27,381	944	1,139
Actual use*	1,153	22,514	461	874
Percent of allocation developed	18%	40%	19%	23%
Water Balance Components (AF/yr)				
Streamflow	70,117	236,842	60,427	93,410
Baseflow portion of streamflow	16,684	53,563	10,785	14,369
Underflow	52,660	150,215	22,716	24,947
Total water resource developed (actual use* as a percent of water balance components):				
Streamflow + Underflow	0.9%	7.8%	0.6%	0.7%
Total water resource allocated (as a percent of water balance components):				
Streamflow + Underflow	5.1%	14.6%	2.9%	3.2%
Groundwater resource allocated (groundwater allocation as a percent of water balance components):				
Streamflow	8.1%	12.2%	2.5%	2.8%
Baseflow + Underflow	8.2%	14.2%	4.5%	6.7%
Baseflow	34.1%	54.1%	13.9%	18.2%
Underflow	10.8%	19.3%	6.6%	10.5%
Runoff resource allocated (surface water allocation as a percent of water balance components):				
Streamflow	0.9%	11.6%	1.6%	1.2%

* Actual use estimates for Case, Skookum and Kennedy Sub-basins includes residential and agricultural use only, and excludes that for commercial and industrial use, which is estimated to be approximately 1-2% of total use based on the proportion of water allocated for this use. Actual use in the Goldsborough Sub-basin is estimated assuming the same ratio of (residential):(commercial and industrial) as between (domestic + municipal):(commercial industrial) allocation.

FIGURES



LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- County Boundaries
- Indian Reservations
- Rivers and Streams
- Water Bodies

0 15

Scale 1" = 15 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

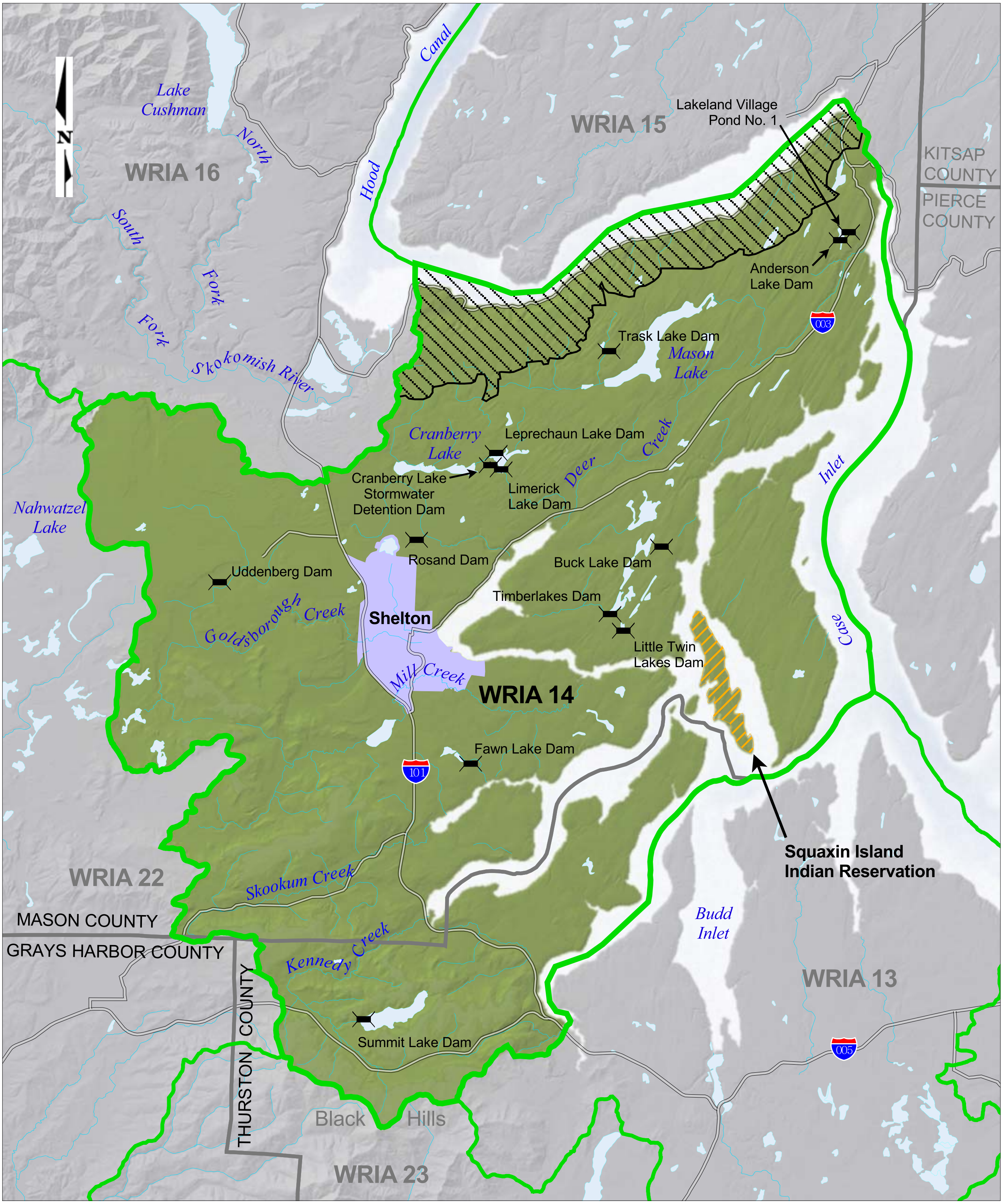
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

Golder Associates

Overview Map

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 1.1

0231147000_071102.apr



LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- County Boundaries
- Reservations
- Urban Areas
- Dams
- Highways
- Rivers and Streams
- Water Bodies

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

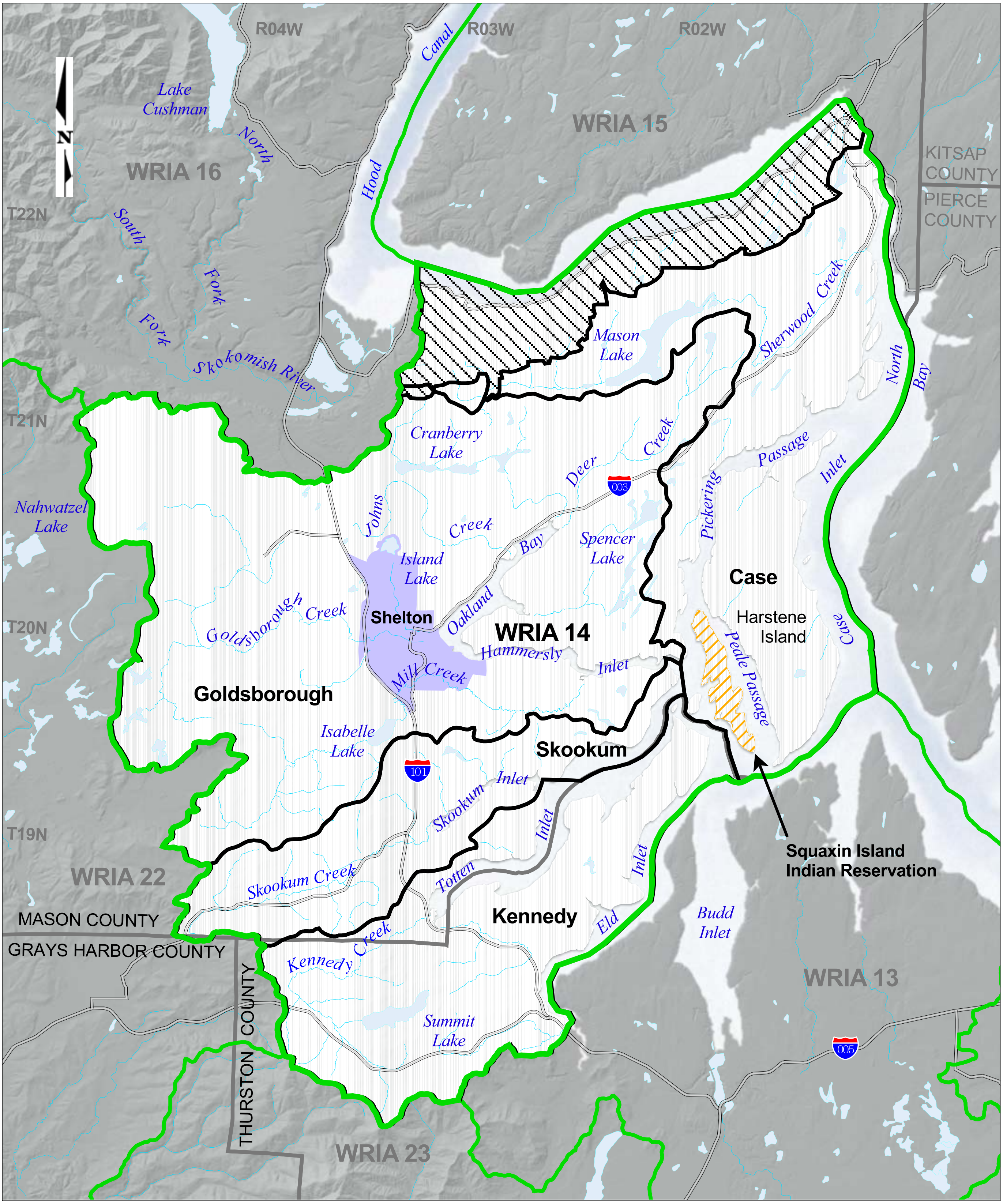
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

Golder Associates

Physiography of the Kennedy Goldsborough Basin

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 1.2

0231147000_071102.apr



LEGEND

WRIA 14	Urban Areas
Covered under WRIA 16 Assessment	Highways
Sub-Basin Boundaries	Rivers and Streams
WRIA Boundaries	Water Bodies
County Boundaries	
Reservations	

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

Golder Associates

Sub-Basin Boundaries

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 1.3

0231147000_071102.apr

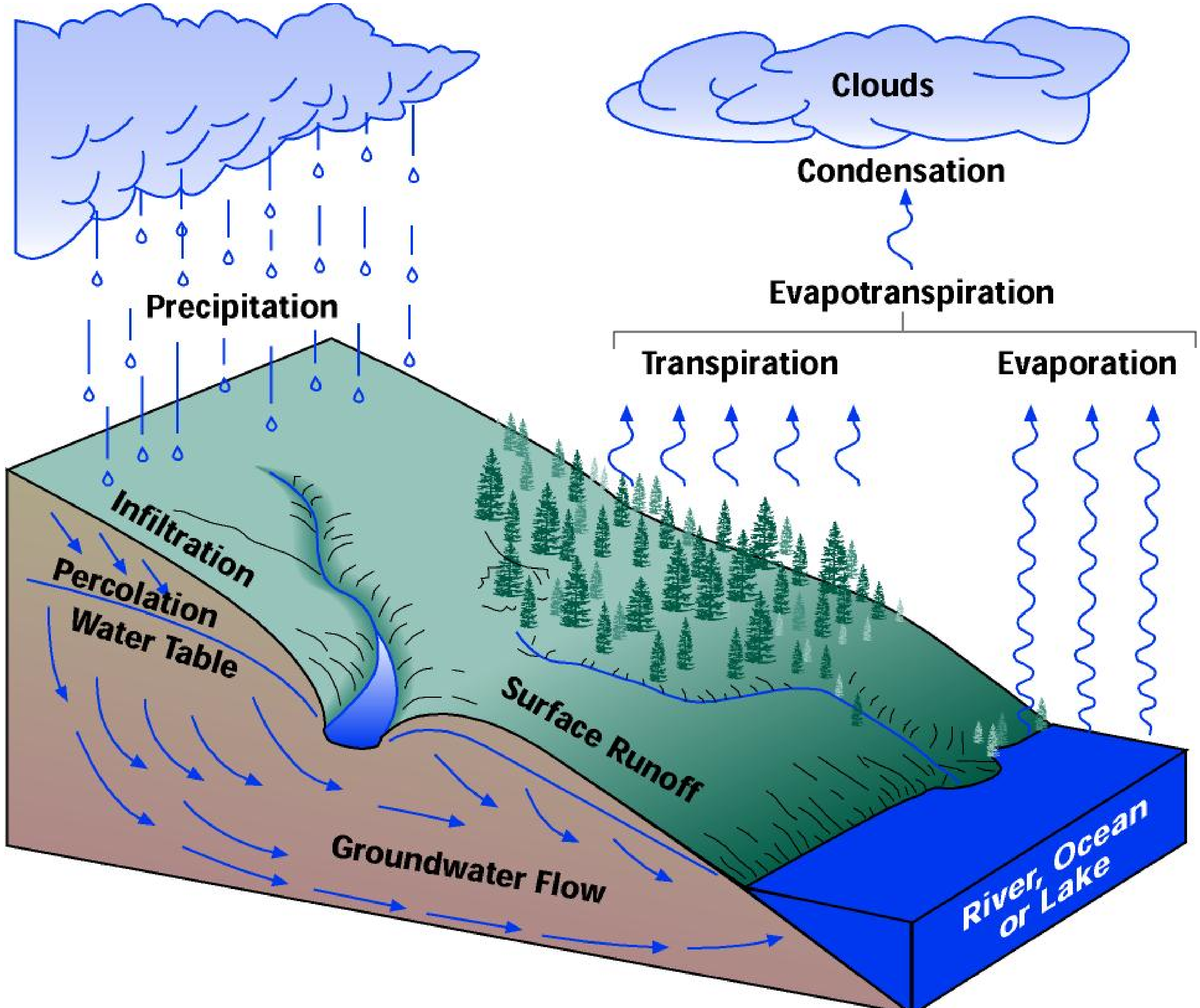
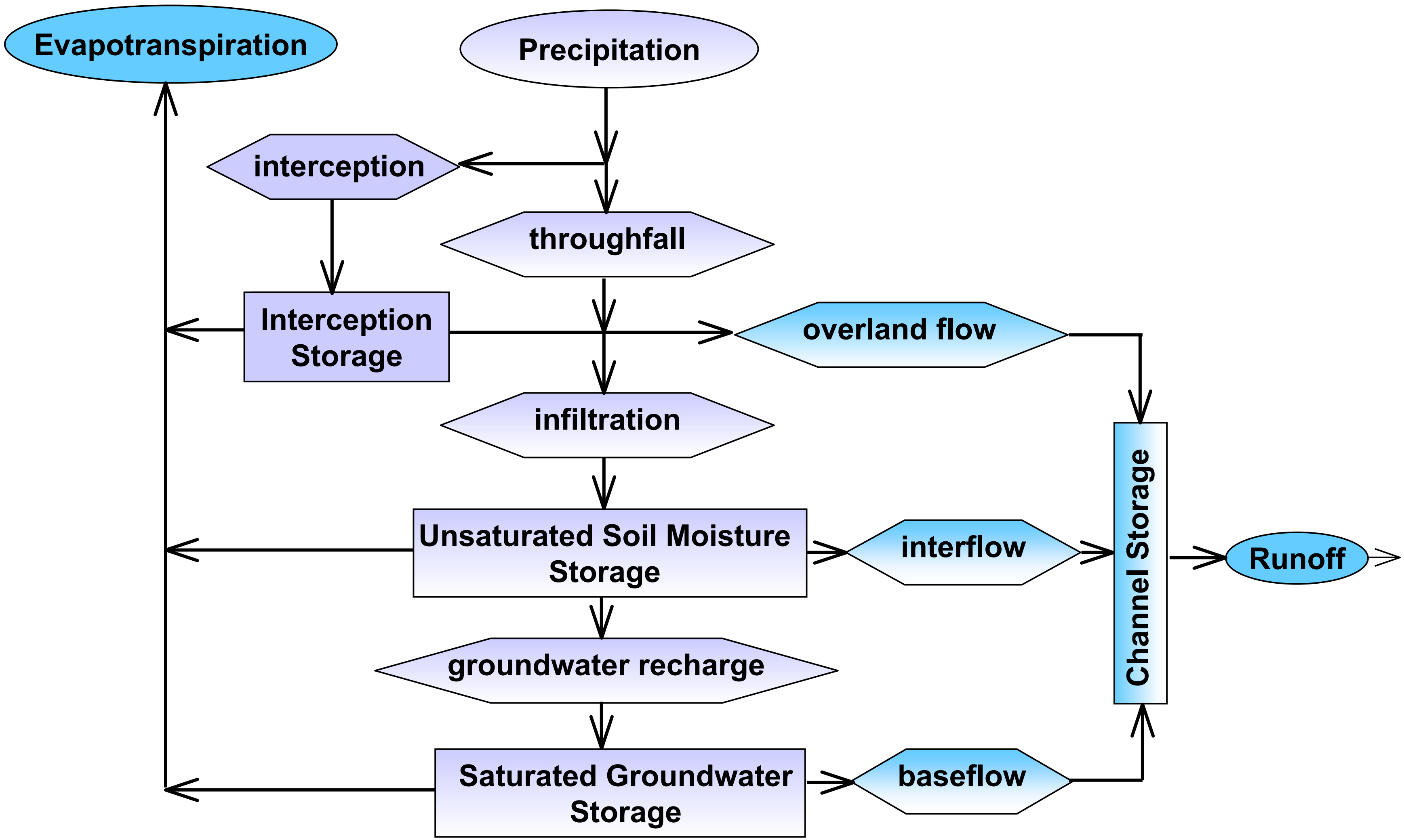


FIGURE **3.1**
HYDROLOGIC CYCLE
MASON/WRIA 14 KENNEDY WATERSHED/WA

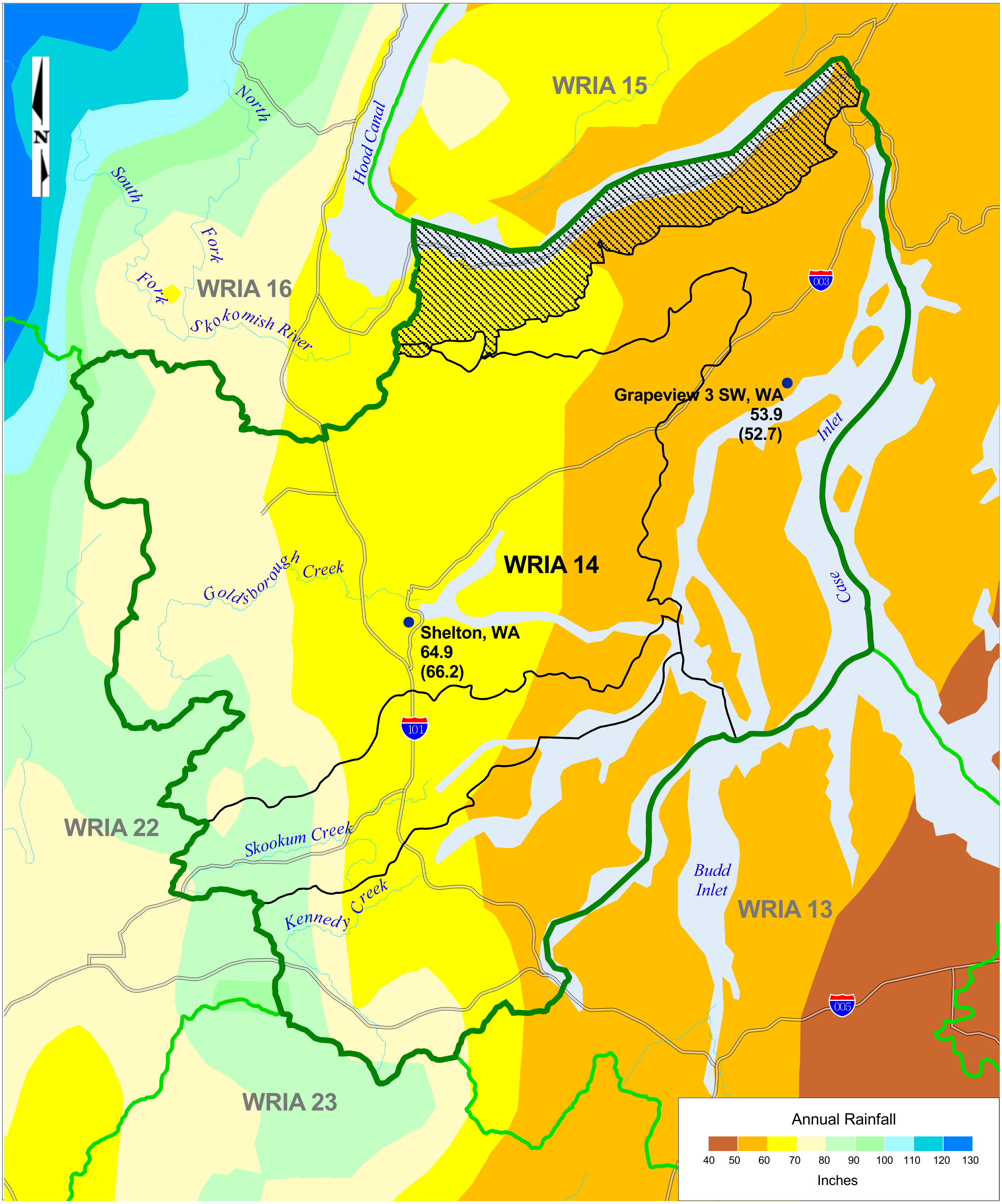
DRAWING NO. 0231147150fg01.fh9 DATE 08/14/02 DRAWN BY ETF

Golder Associates



Adapted from Freeze and Cherry, 1978.

FIGURE **3.2**
SYSTEMS REPRESENTATION OF THE HYDROLOGIC CYCLE
MASON/WRIA 14 KENNEDY WATERSHED/WA



LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- Sub-Basin Boundaries
- Highways
- WRIA 14
- Waterbodies
- Western Region Climate Source Precipitation Stations
- 50.5 PRISM Average Annual
- (50.5) Western Region Climate Source Average Annual

0 4

Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

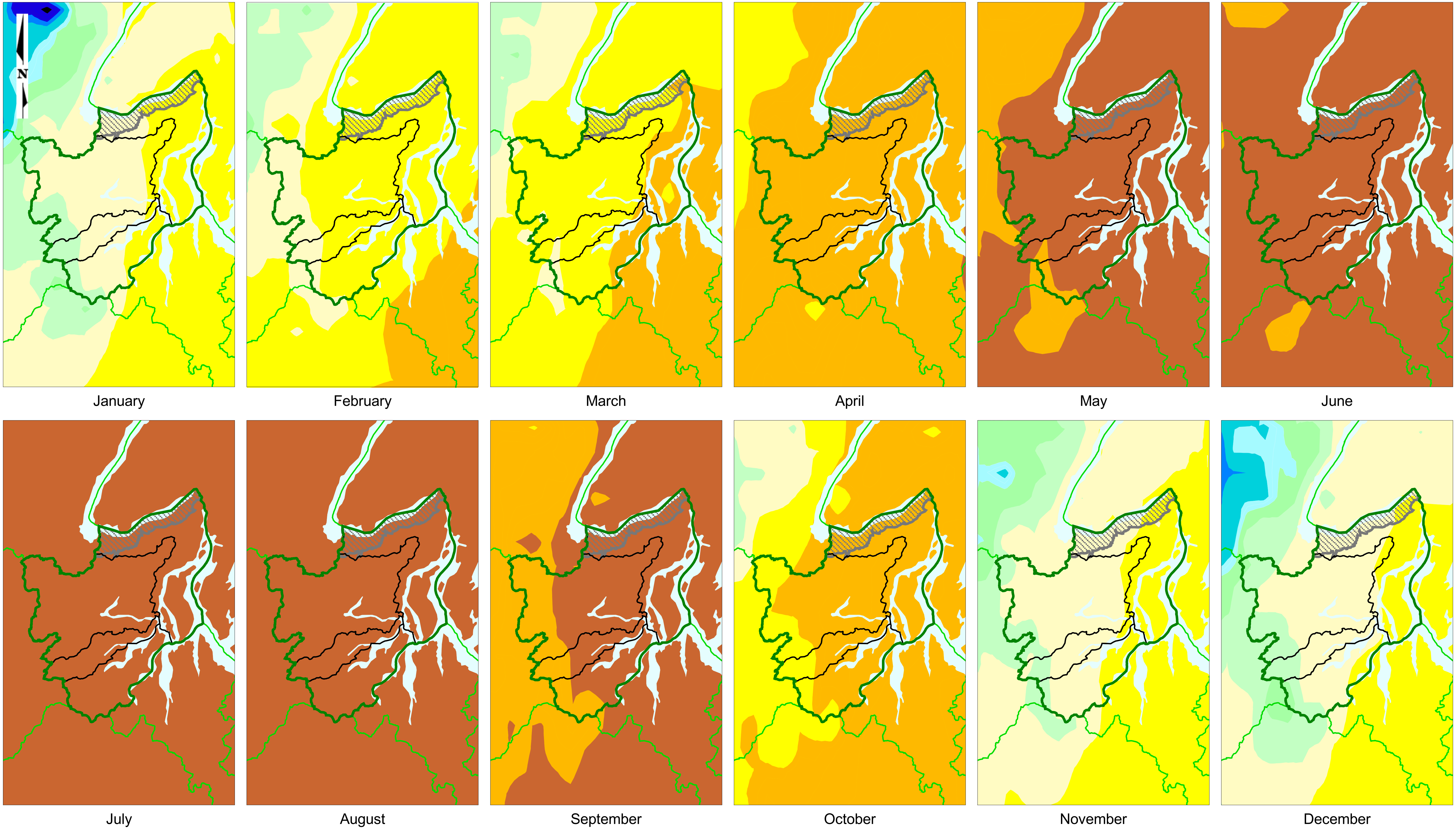
Original Data Source: Climate Source Inc, Washington Department of Ecology, Washington Department of Transportation

Golder Associates

Average Annual PRISM Precipitation

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 4.1

0231147000_071102.apr



LEGEND

WRIA 14

Sub-Basin Boundaries

Covered under WRIA 16 Assessment

WRIA Boundaries

Monthly Rainfall

0 3 6 9 12 15 18 21 24 27 30 33

Total Inches

0 15

Scale 1" = 15 Miles

N

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Map Projection: Washington State Plane North Zone, NAD83, Feet

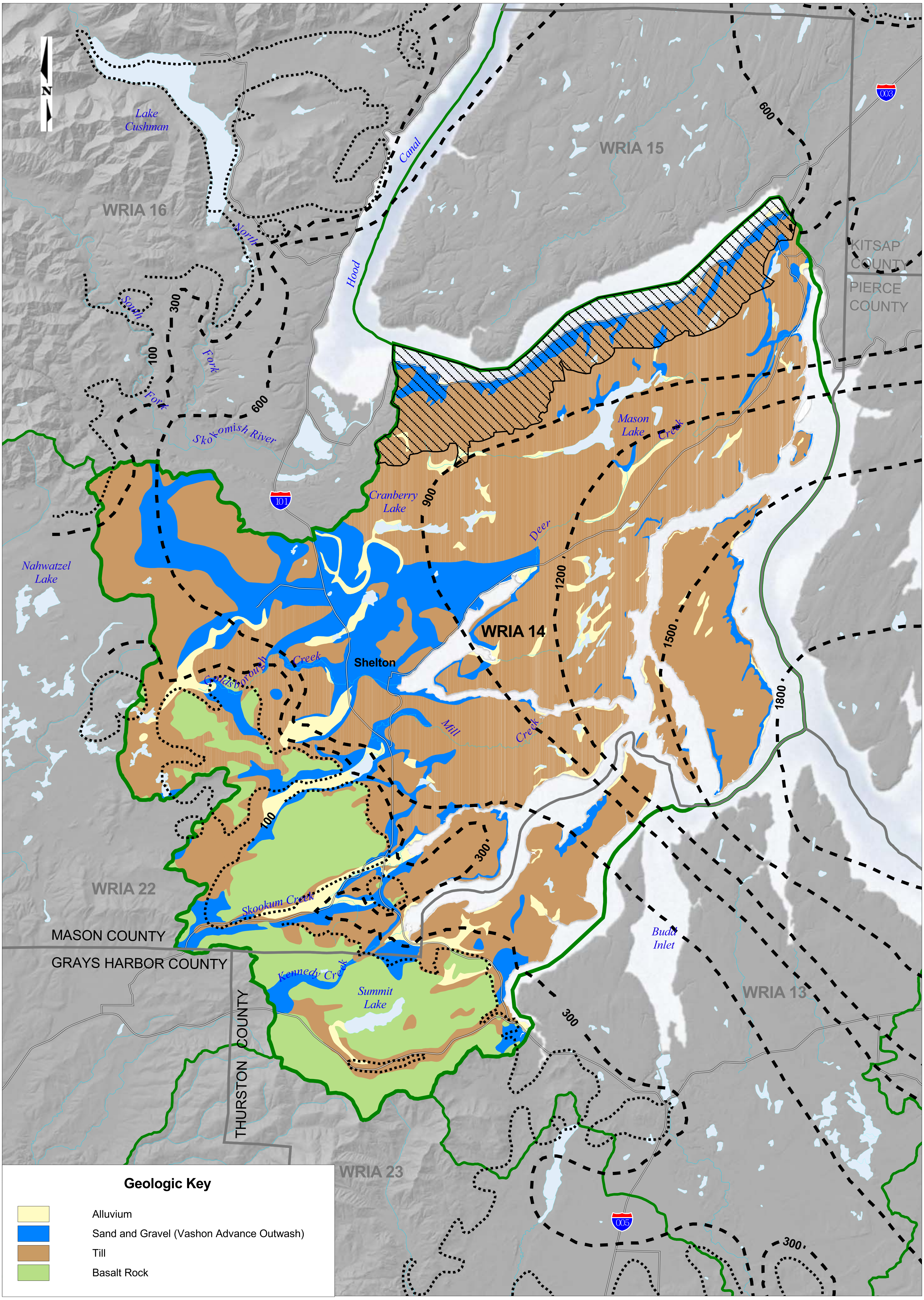
Original Data Source: Climate Source Inc, Washington State Dept of Ecology, Washington State Dept of Transportation

Golder Associates

Average Monthly PRISM Precipitation

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 4.2

0231147000_071102.apr



The figure was originally produced in color. Reproduction in black and white may result in loss of information

LEGEND

- Thickness of Unconsolidated Sediment (>100 ft)
- Thickness of Unconsolidated Sediment (100 ft)
- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- County Boundaries
- Highways
- Rivers and Streams
- Waterbodies

0 3
Scale 1" = 3 Miles

Original Data Source: Washington State DOT, Washington State Dept. of Ecology, WRATS, Washington Dept. of Natural Resources, Jones (1996)

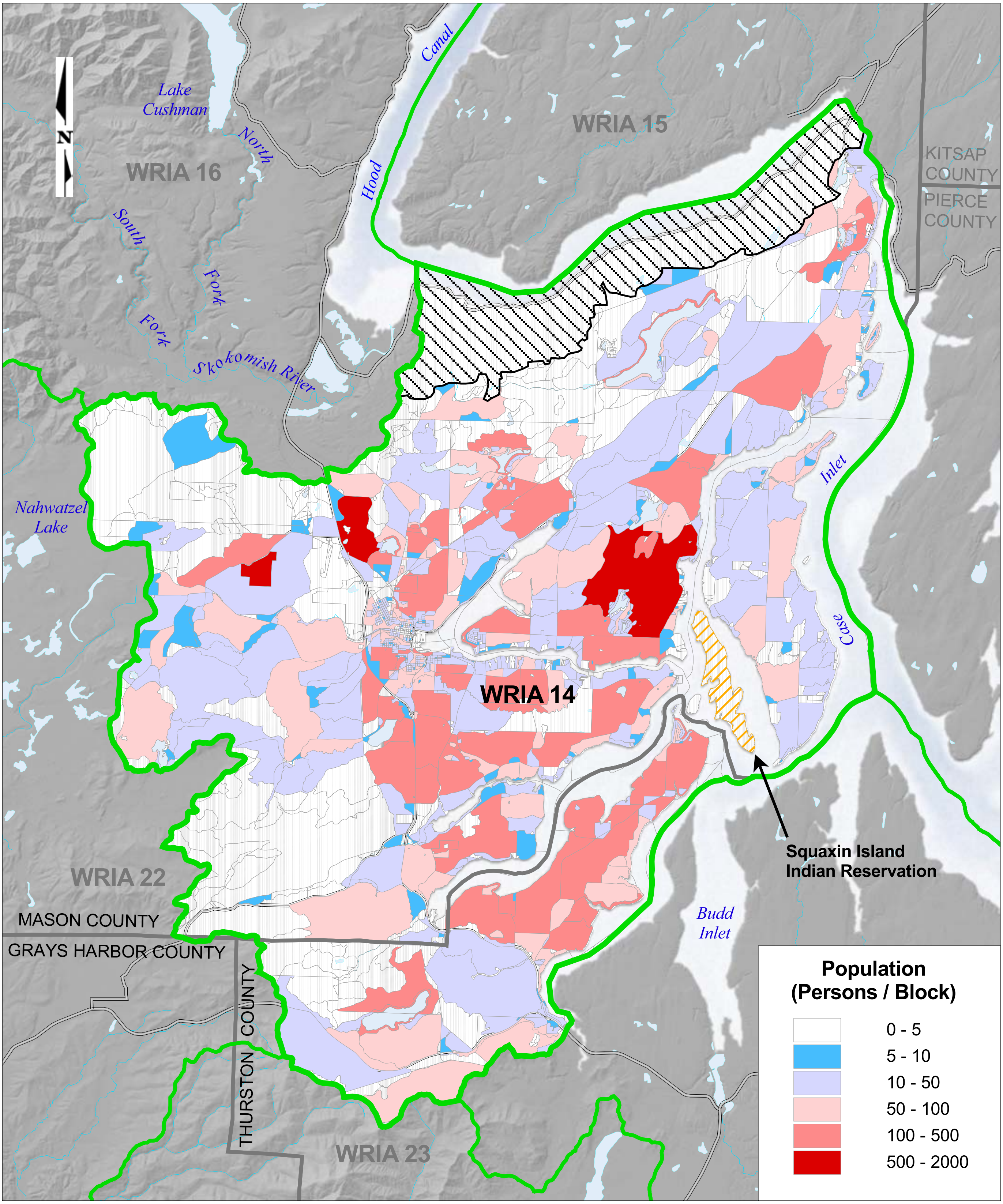
Map Projection: Washington State Plane, NAD83, North, Feet

Golder Associates

Aggregated 100K Geology

Drawn: ATB	Revision: 2	Date: Sep 23, 2002	Figure: 4.3

0231147000_071102.apr



LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- County Boundaries
- Reservations
- Highways
- Rivers and Streams
- Water Bodies

0 4

Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

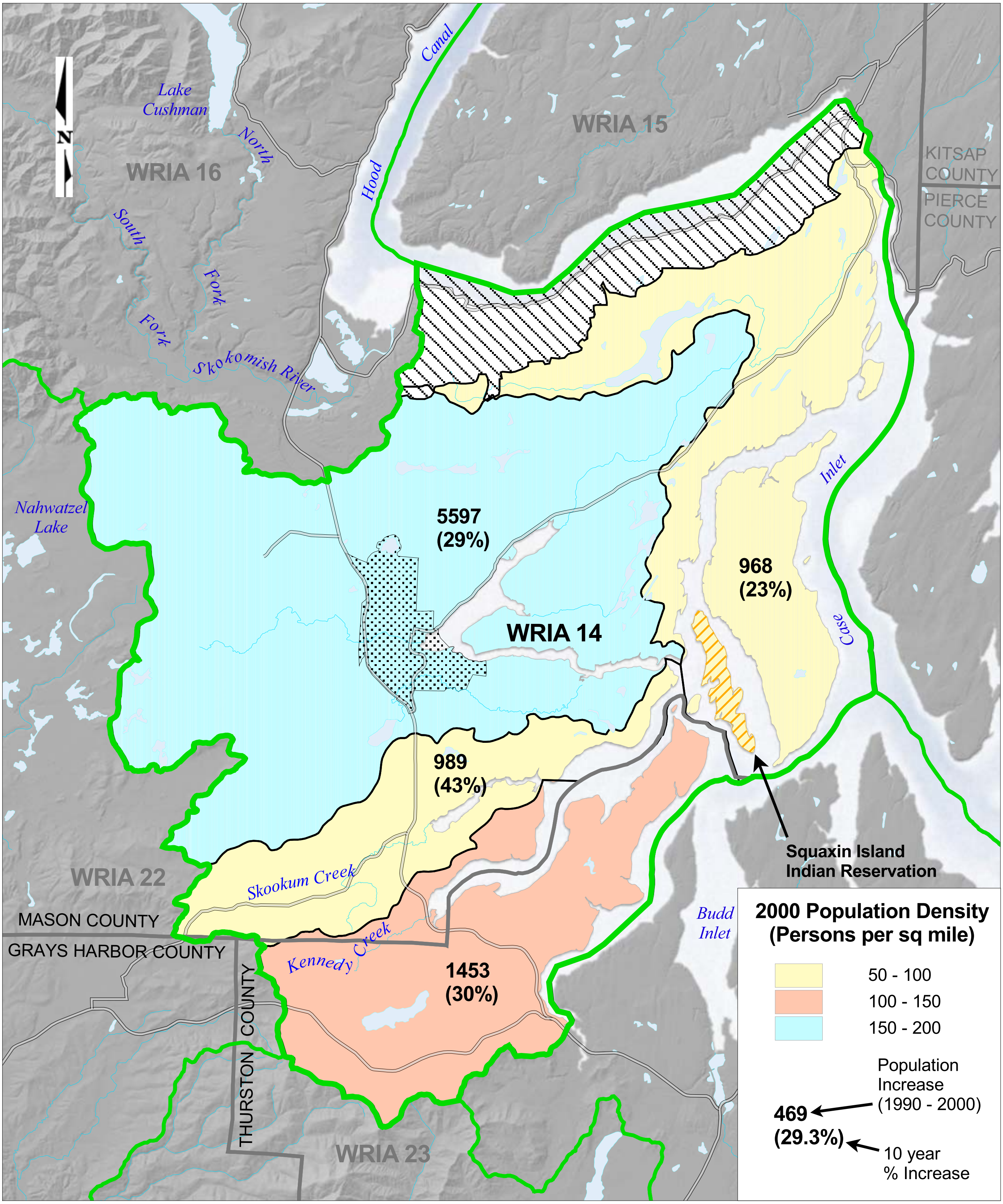
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation Washington Dept. of Health, US 2000 Census

Golder Associates

Population (Census 2000)

Drawn: GKL	Revision: 2	Date: Aug 09, 2002	Figure: 4.4

0231147000_071102.apr



LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- Sub-Basin Boundaries
- County Boundaries
- Shelton
- Reservations
- Highways
- Rivers and Streams
- Water Bodies

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

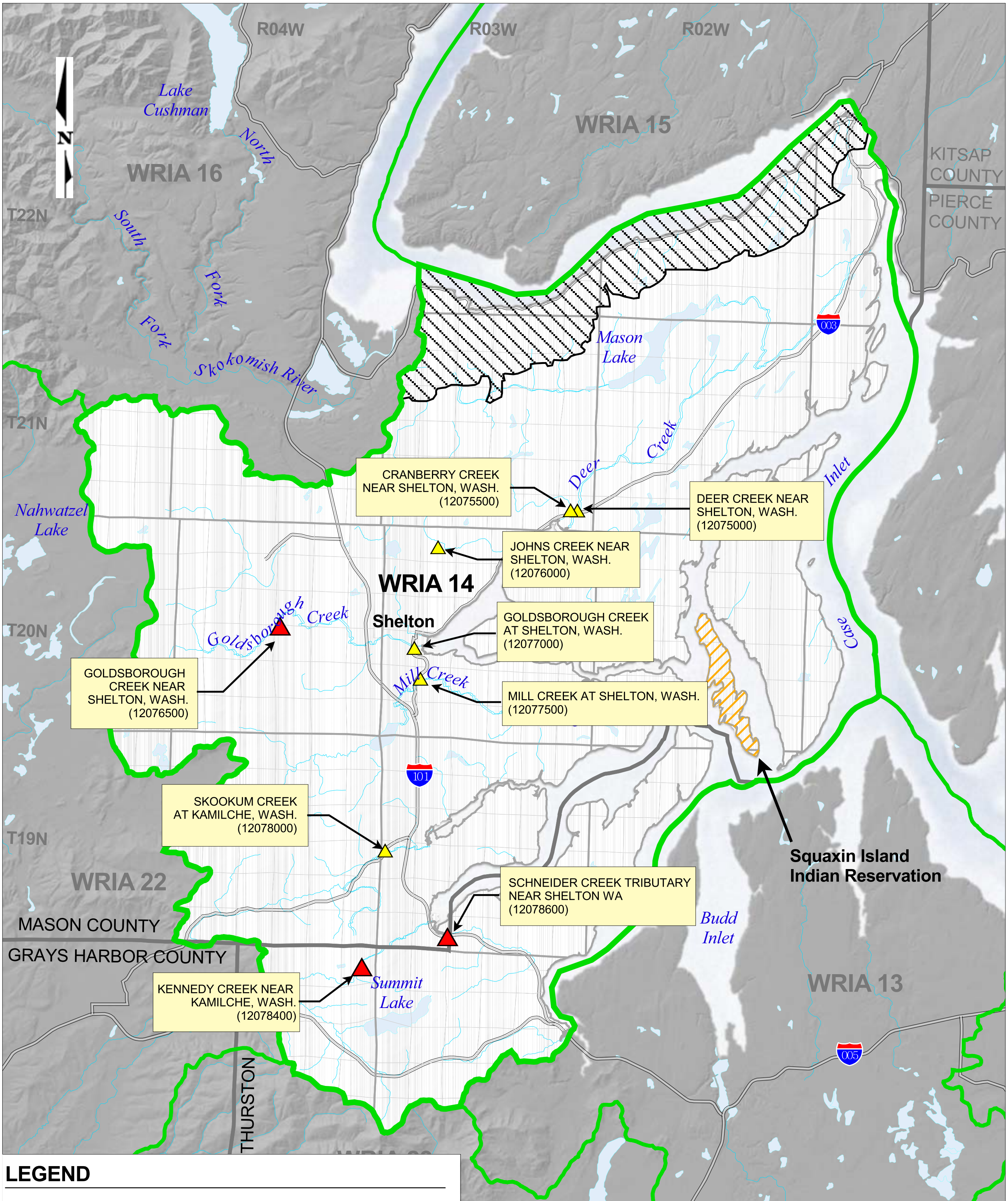
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation Washington Dept. of Health, US 2000 Census

Golder Associates

Population Growth (1990 - 2000)

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 4.5

0231147000_071102.apr



LEGEND

- USGS Gauging Stations with <10 yr Period of Record
- USGS Gauging Stations with >10 yr Period of Record
- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- County Boundaries
- Reservations
- Townships
- Sections
- Highways
- Rivers and Streams
- Water Bodies

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

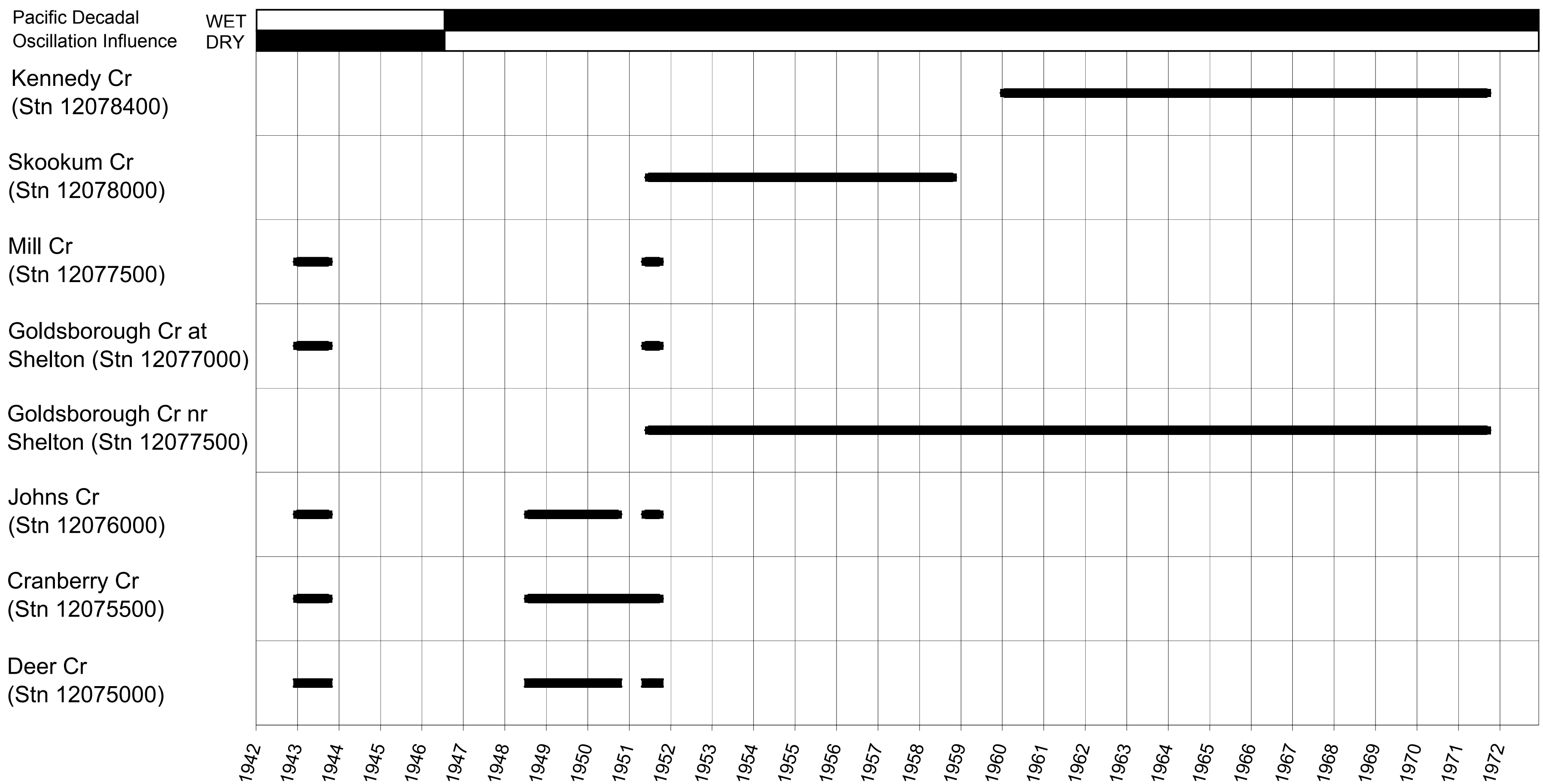
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation USGS

Golder Associates

USGS Stream Gauging Stations

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 5.1

0231147000_071102.apr



Legend

FIGURE 5.2: USGS Stream Gaging Periods of Record

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates

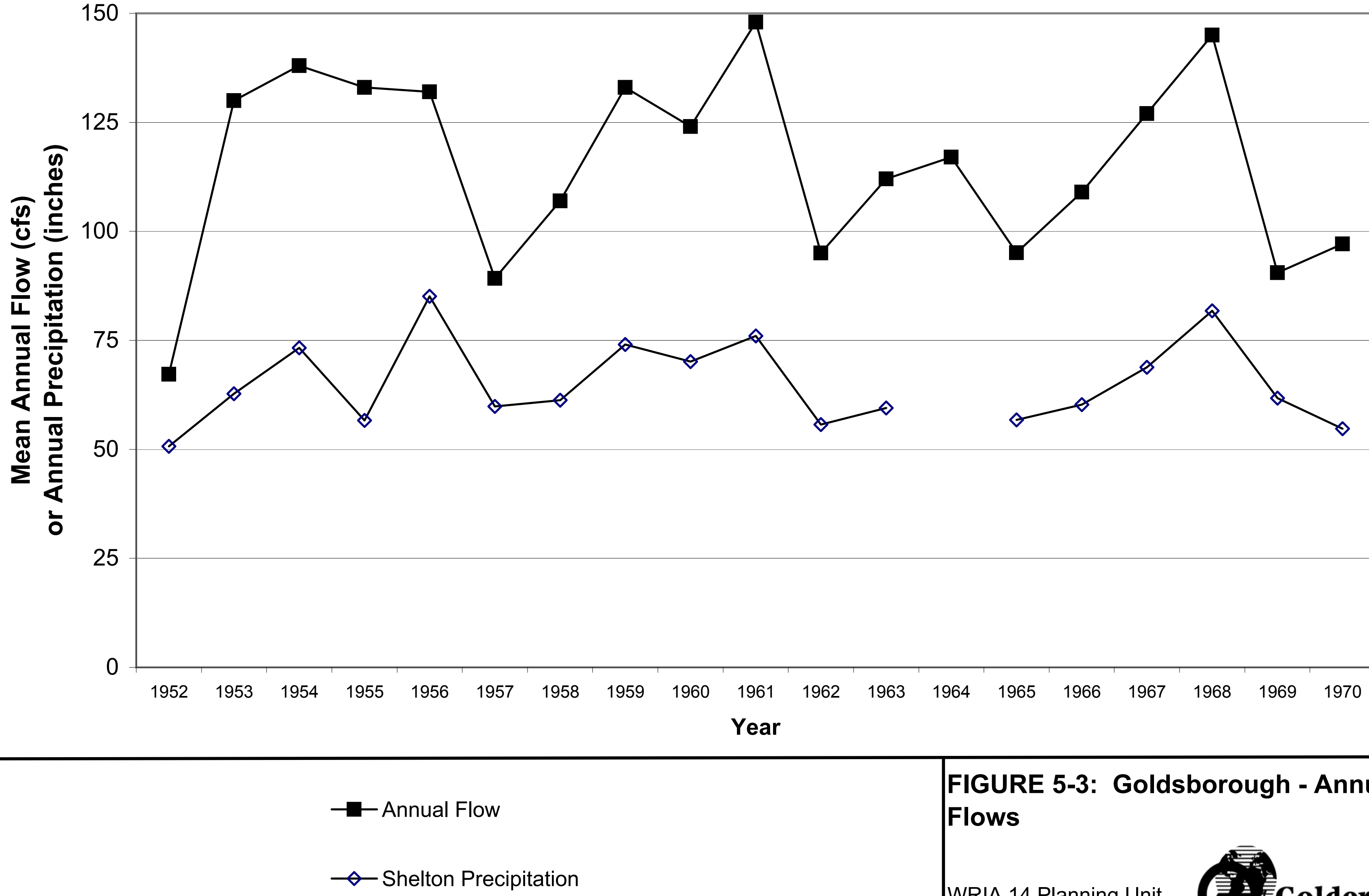
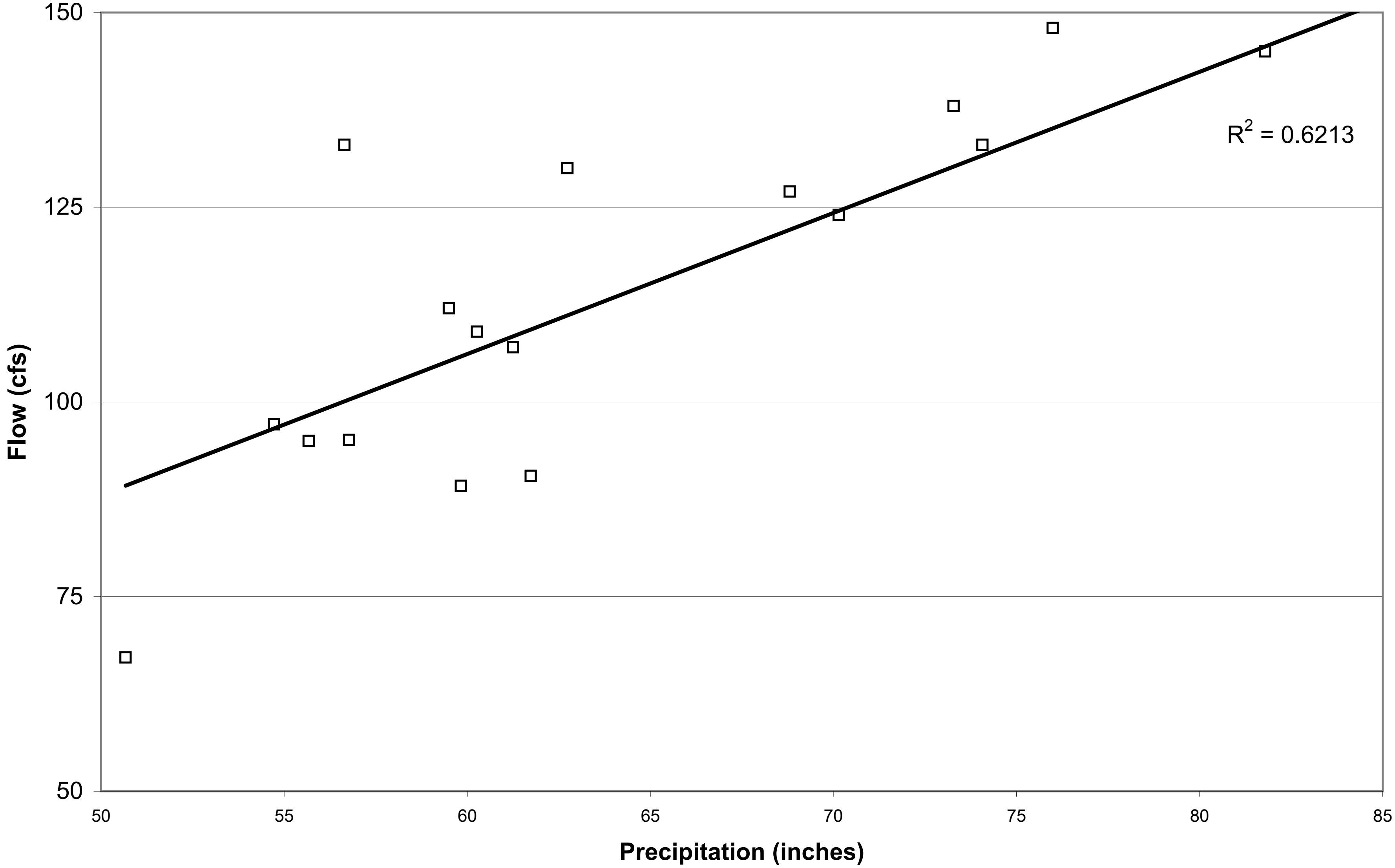


FIGURE 5-3: Goldsborough - Annual Flows

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



Legend

Annual Flow

Linear (Annual Flow)

FIGURE 5-3a: Goldsborough - Annual Flows vs. Precipitation

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates

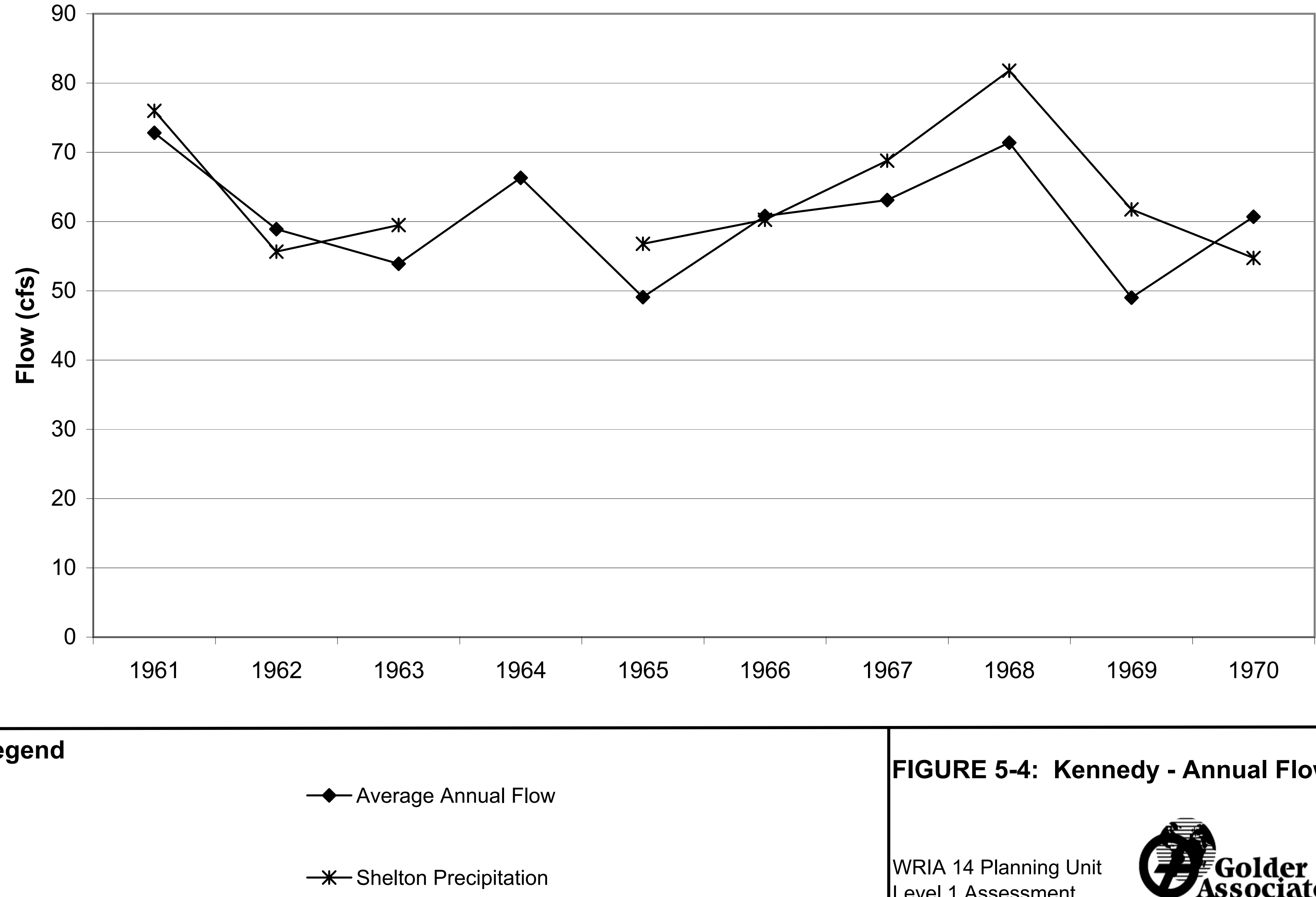


FIGURE 5-4: Kennedy - Annual Flows

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates

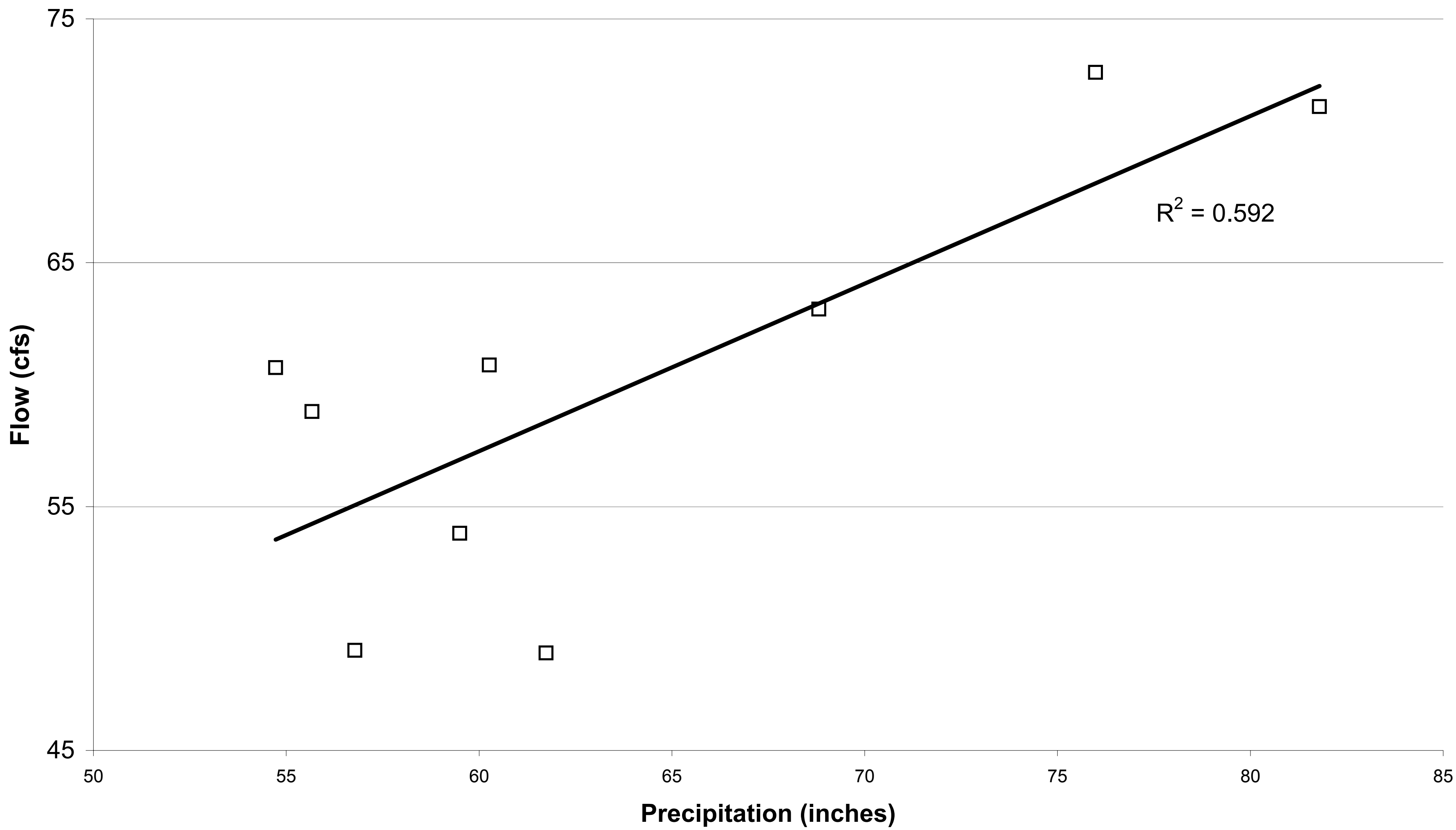
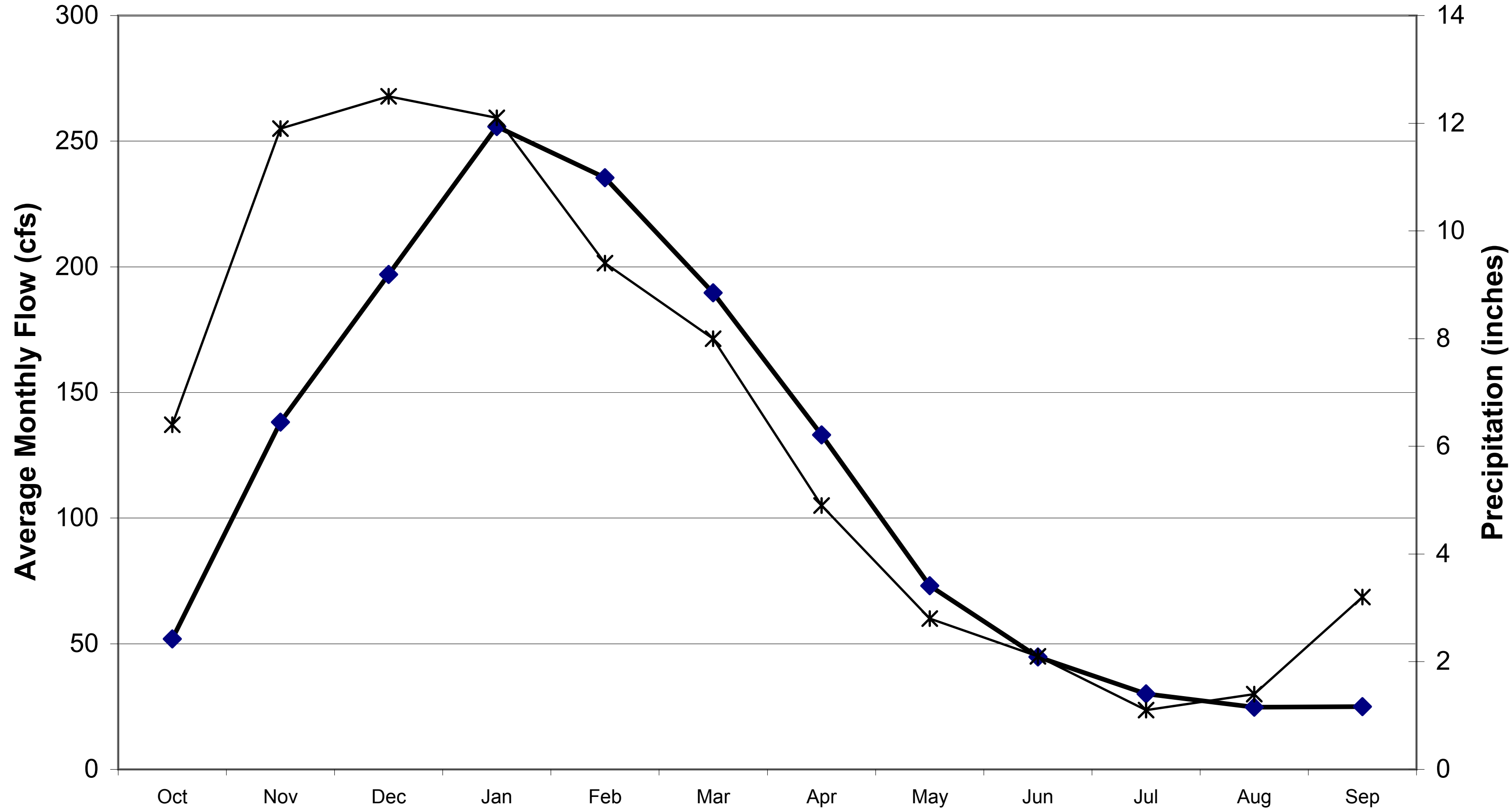


FIGURE 5-4a: Kenedy - Annual Flows vs. Precipitation

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



Legend

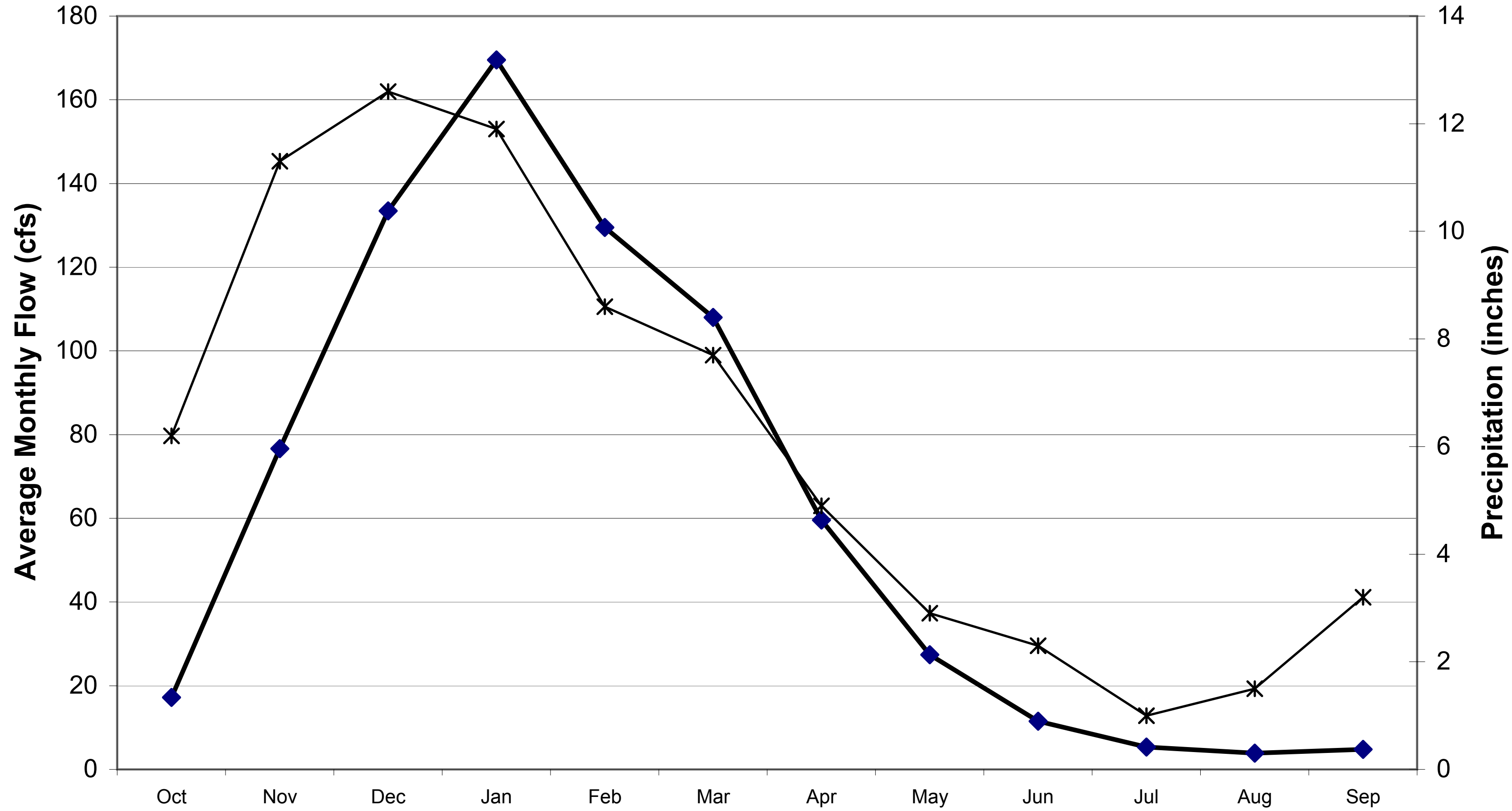
Average Monthly Flow

Average monthly precipitation in the Upper Goldsborough drainage

FIGURE 5-5: Goldsborough - Average Monthly Flows

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



Legend

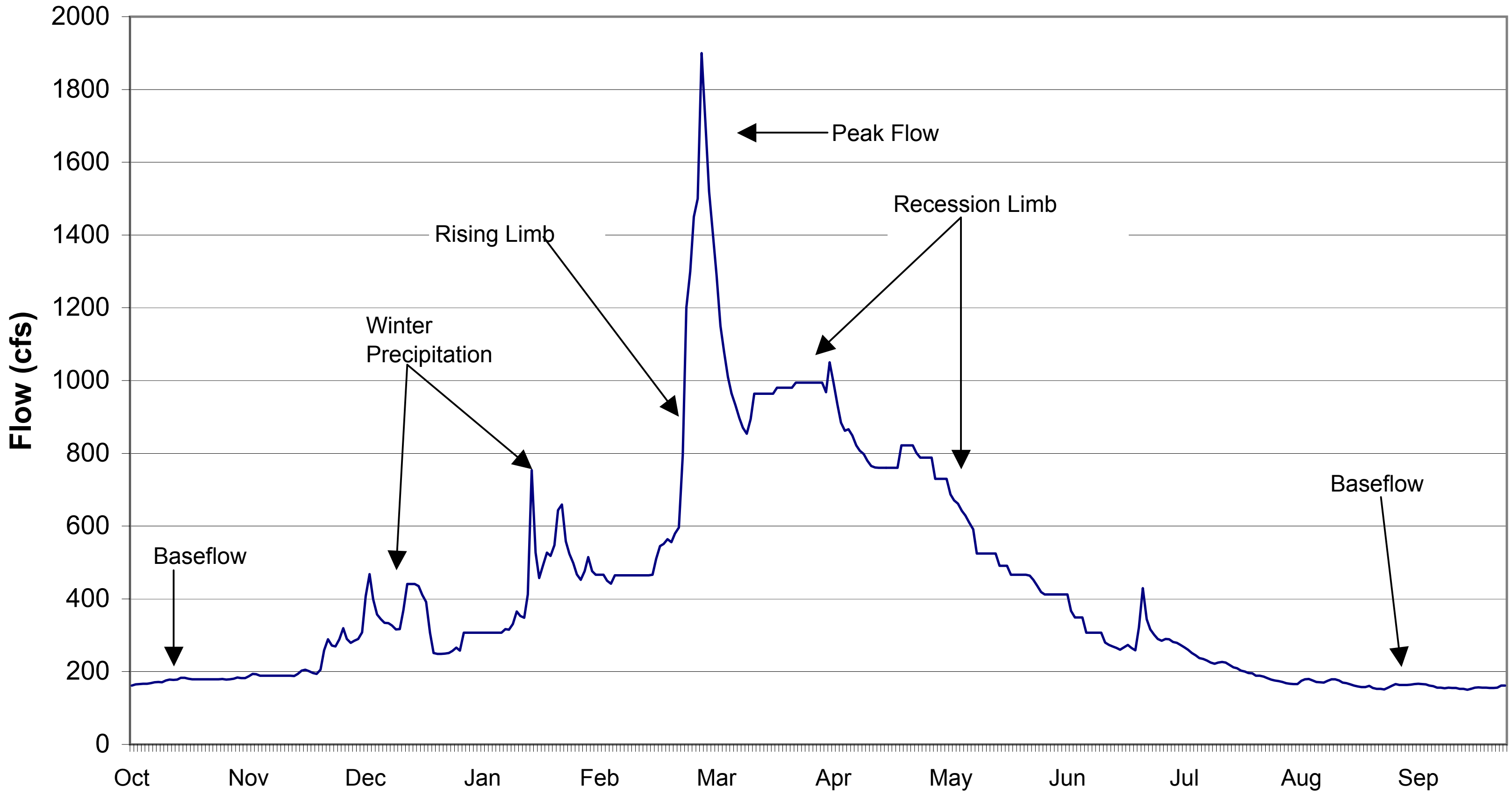
Average Monthly Flow

Average monthly PRISM precipitation in the Upper Kennedy catchment

FIGURE 5-6: Kennedy - Average Monthly Flows

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates

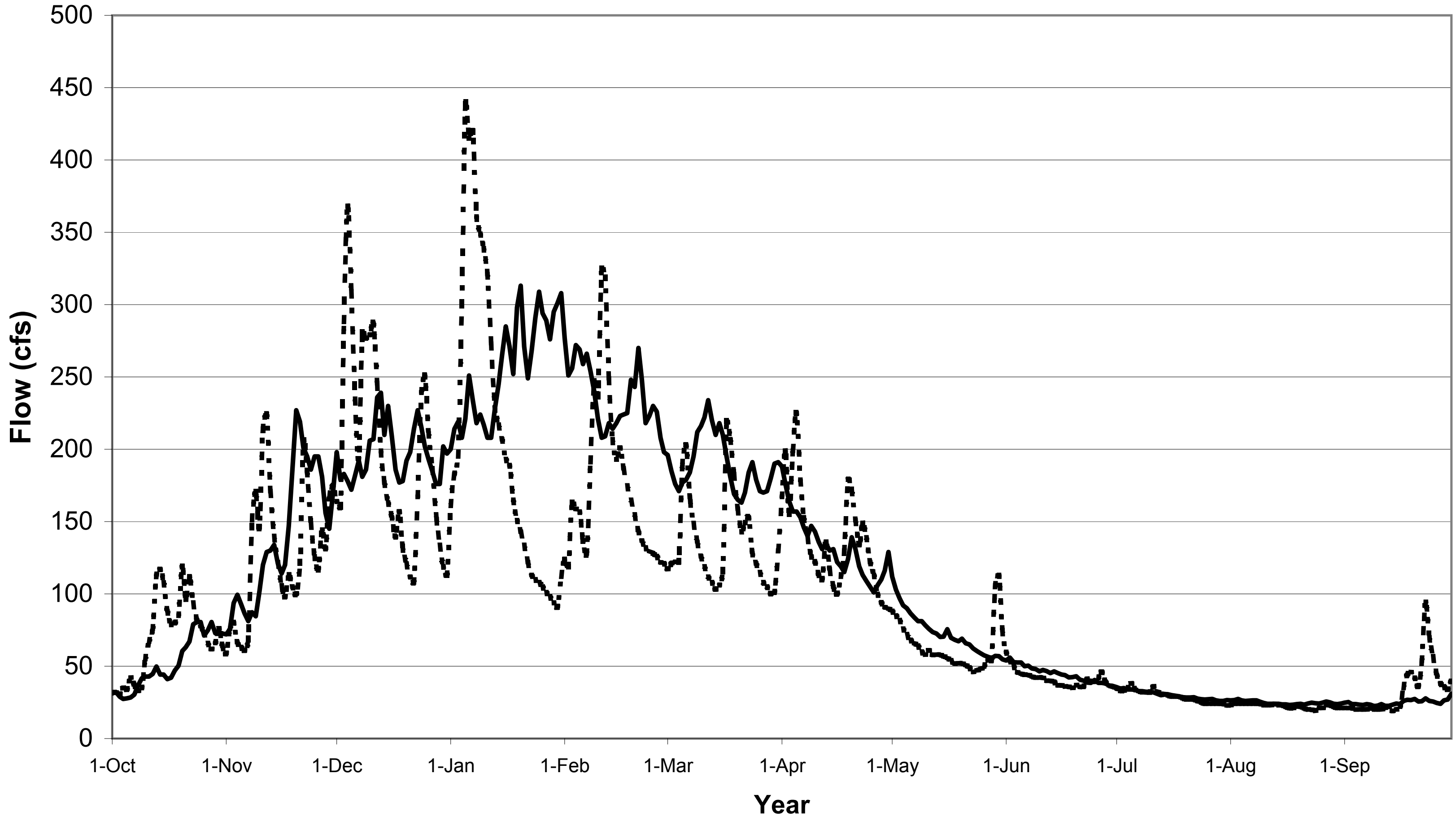


Legend

FIGURE 5-7: Typical Hydrograph Components

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



Legend

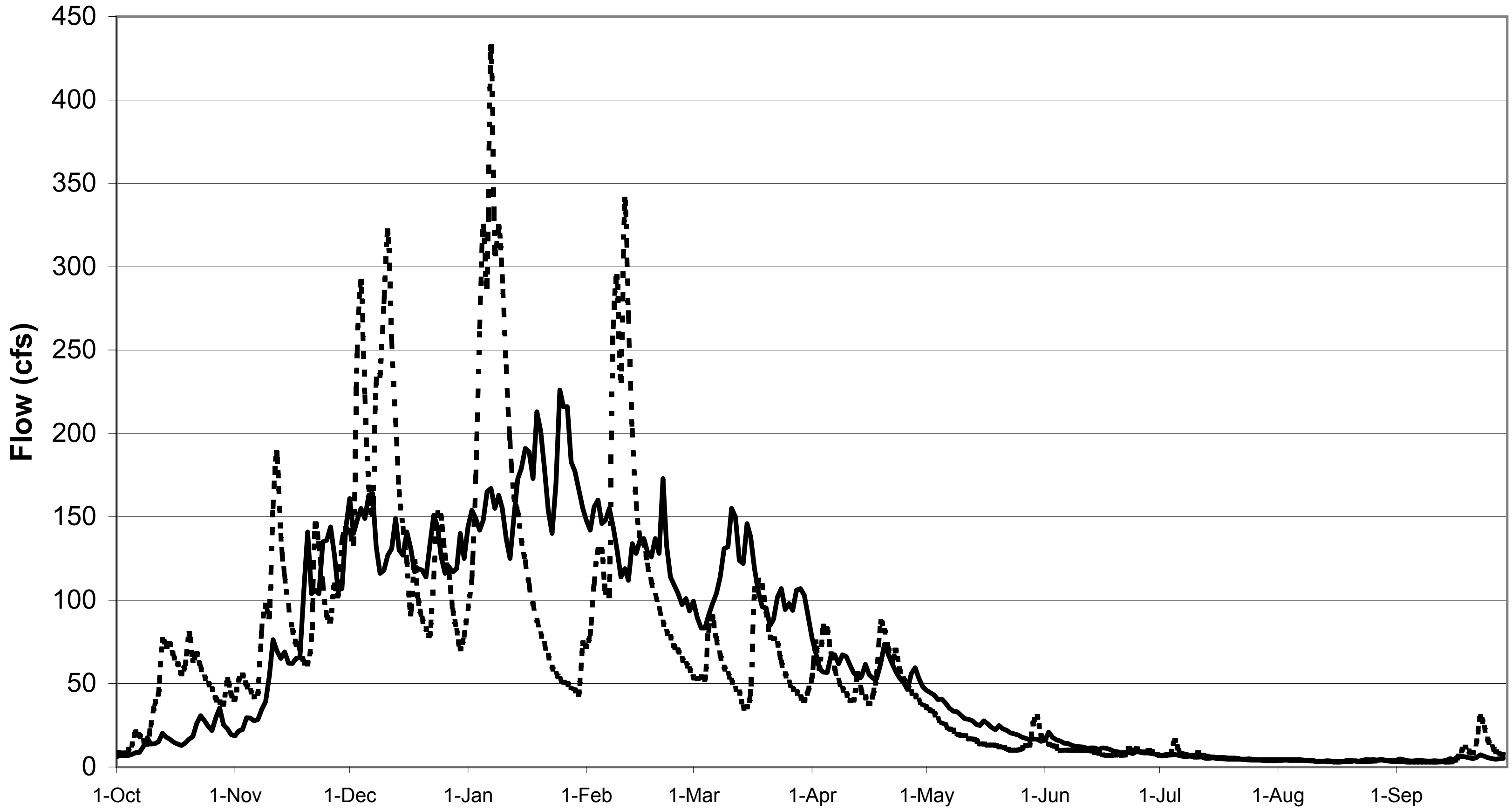
Average Daily Flow

Daily flows 1969 hydrologic Year

FIGURE 5.8: Goldsborough - Daily Flows

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



Legend

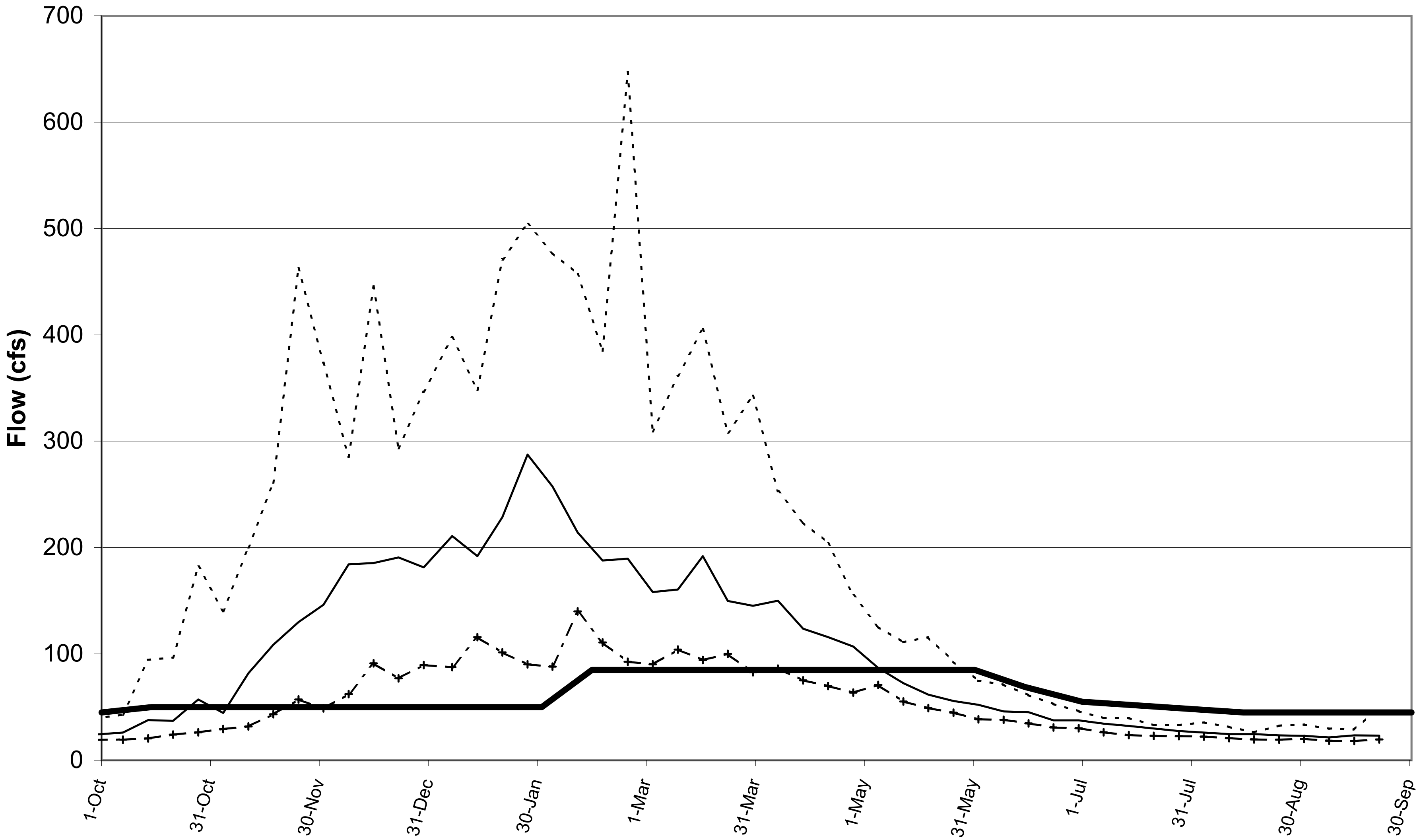
Average Daily Flow

Daily flows 1969 hydrologic year

FIGURE 5-9: Kennedy - Daily Flows

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



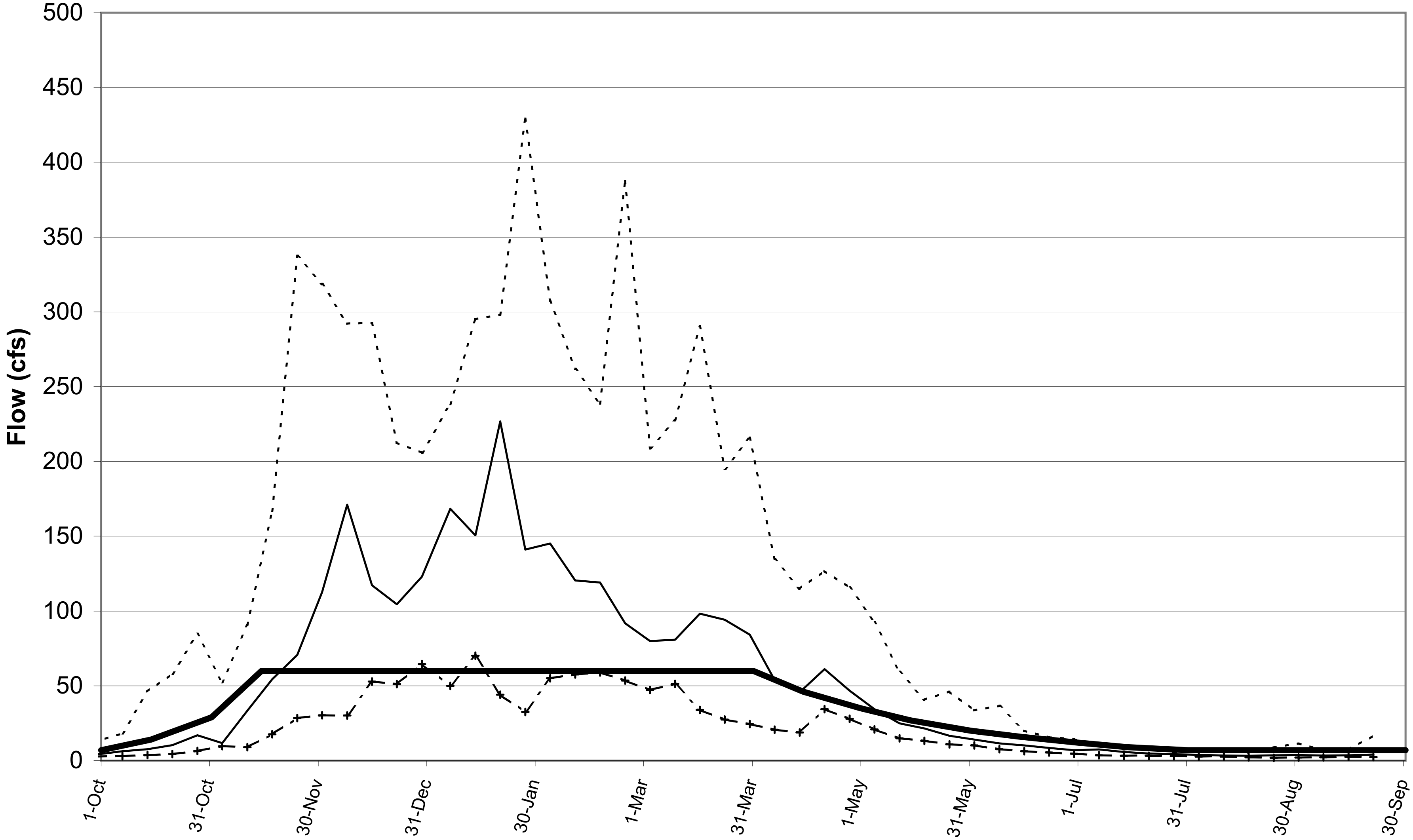
Legend

10% Exceedance Flow
50% Exceedance Flow
90% Exceedance Flow
Minimum Instream Flow Requirement

FIGURE 5-10: Goldsborough - Exceedance Curves

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



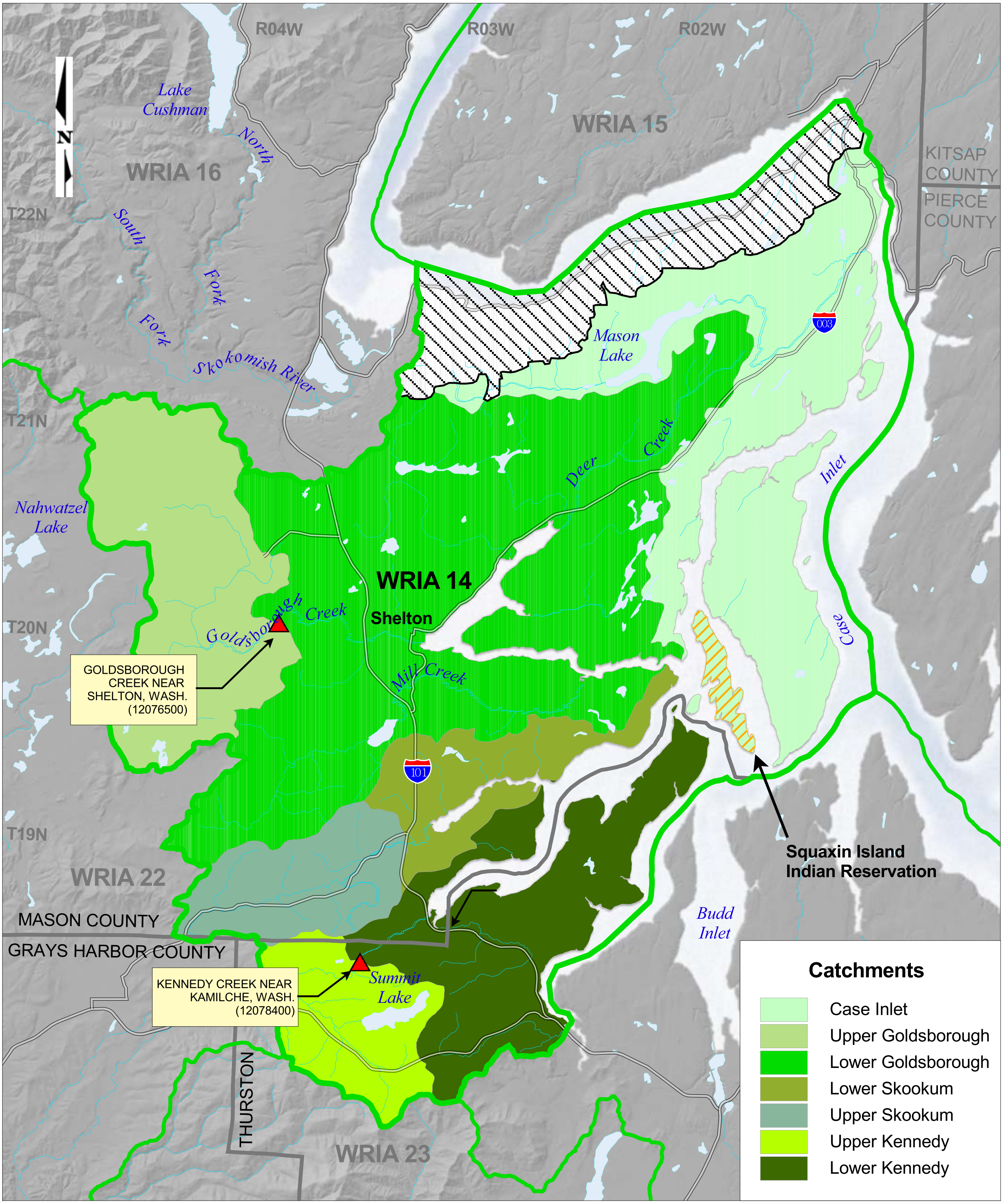
Legend

- 10 % Exceedance Flow
- 50% Exceedance Flow
- 90% Exceedance Flow
- Minimum Instream Flow Requirement

FIGURE 5-11: Kennedy - Exceedance Curves

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



LEGEND

- USGS Gauging Stations with ≥10 yr Period of Record
- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- County Boundaries
- Reservations
- Highways
- Rivers and Streams
- Water Bodies

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

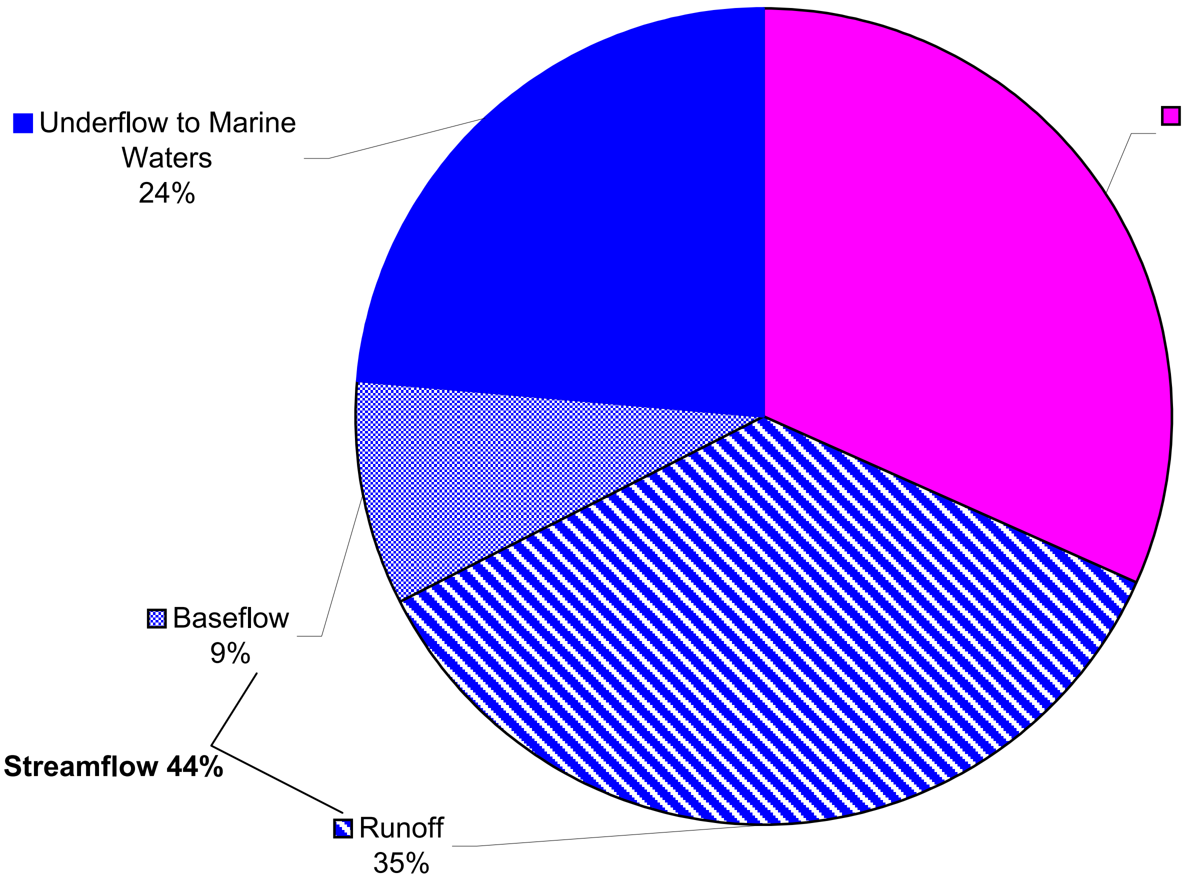
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation, USGS

Golder Associates

Catchments Assessed for Water Balance

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 6.1

0231147000_071102.apr

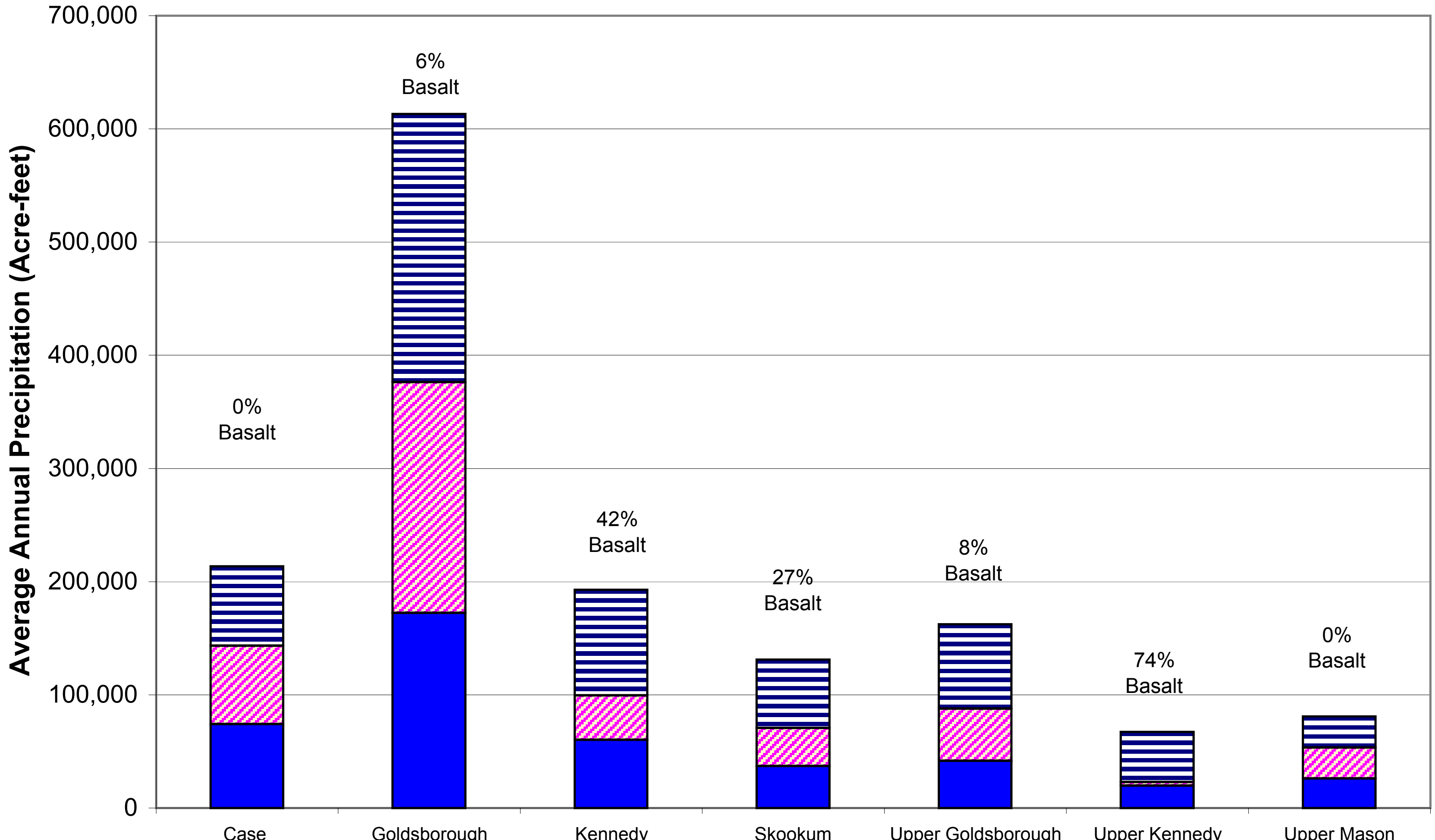


Annual Watershed Precipitation = 1,446,960 Acre-feet

FIGURE 6-2: Water Balance Summary for WRIA 14

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



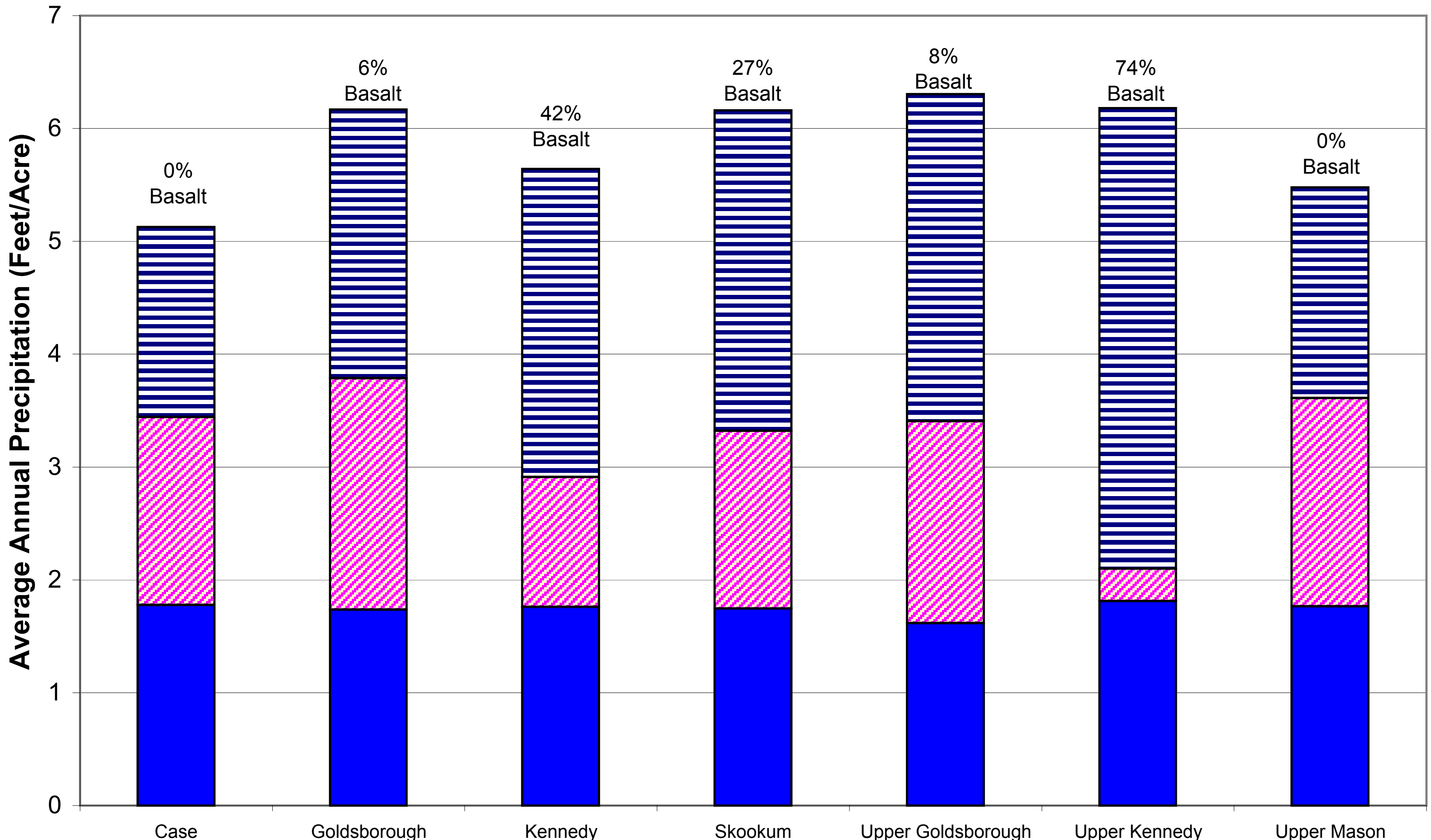
Legend

- Streamflow
- Groundwater Residual
- Blaney-Criddle Actual Evapotranspiration

FIGURE 6-3: Water Balance Components by Catchment

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



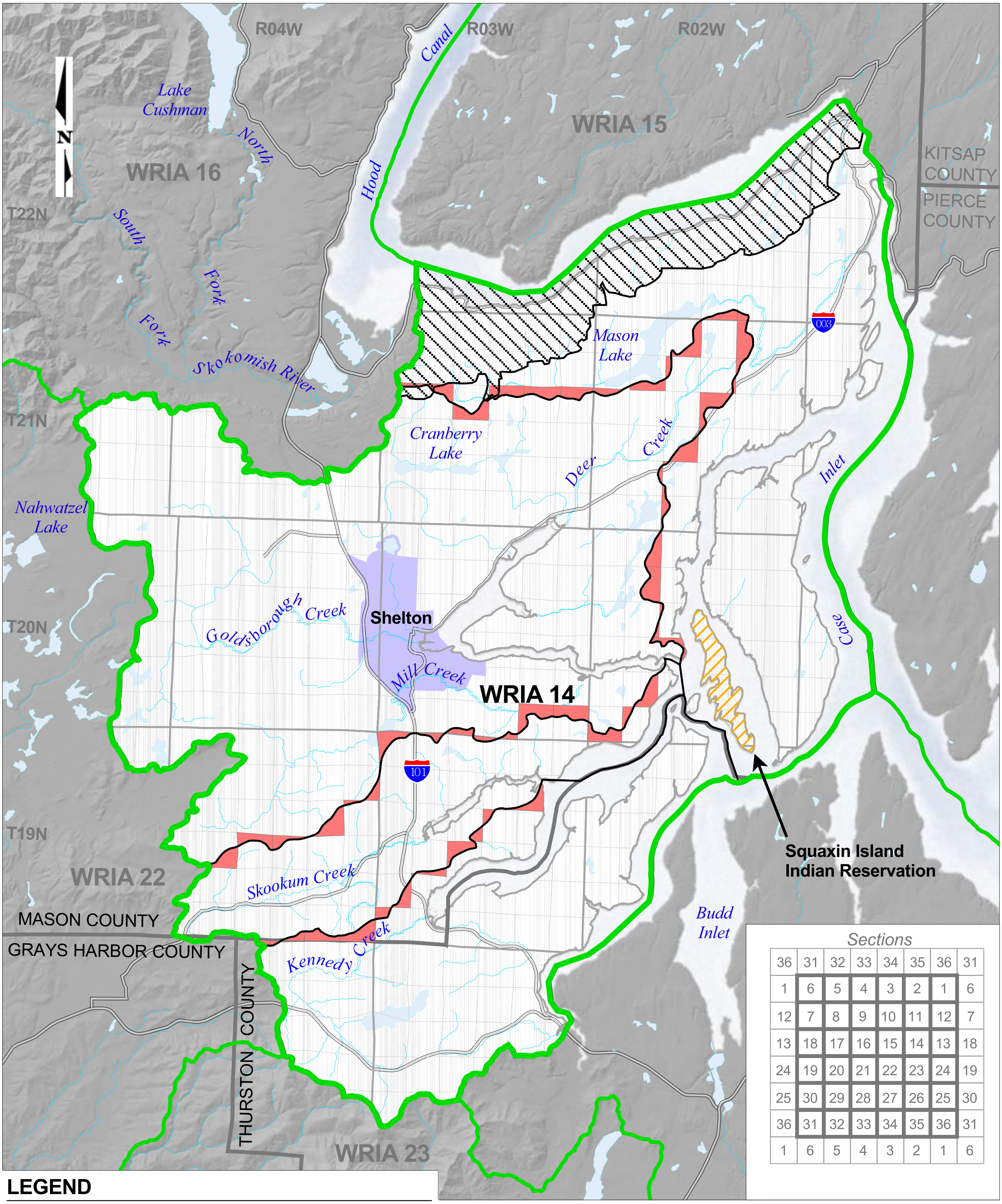
Legend

- Streamflow
- Groundwater Residual
- Blaney-Criddle Actual Evapotranspiration

FIGURE 6-4: Normalized Water Balance

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



LEGEND

- Portions of sections included in a different subbasin
- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- Sub-Basin Boundaries
- County Boundaries
- Reservations
- Urban Areas
- Highways
- Rivers and Streams
- Water Bodies
- Townships
- Sections

0 4

Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

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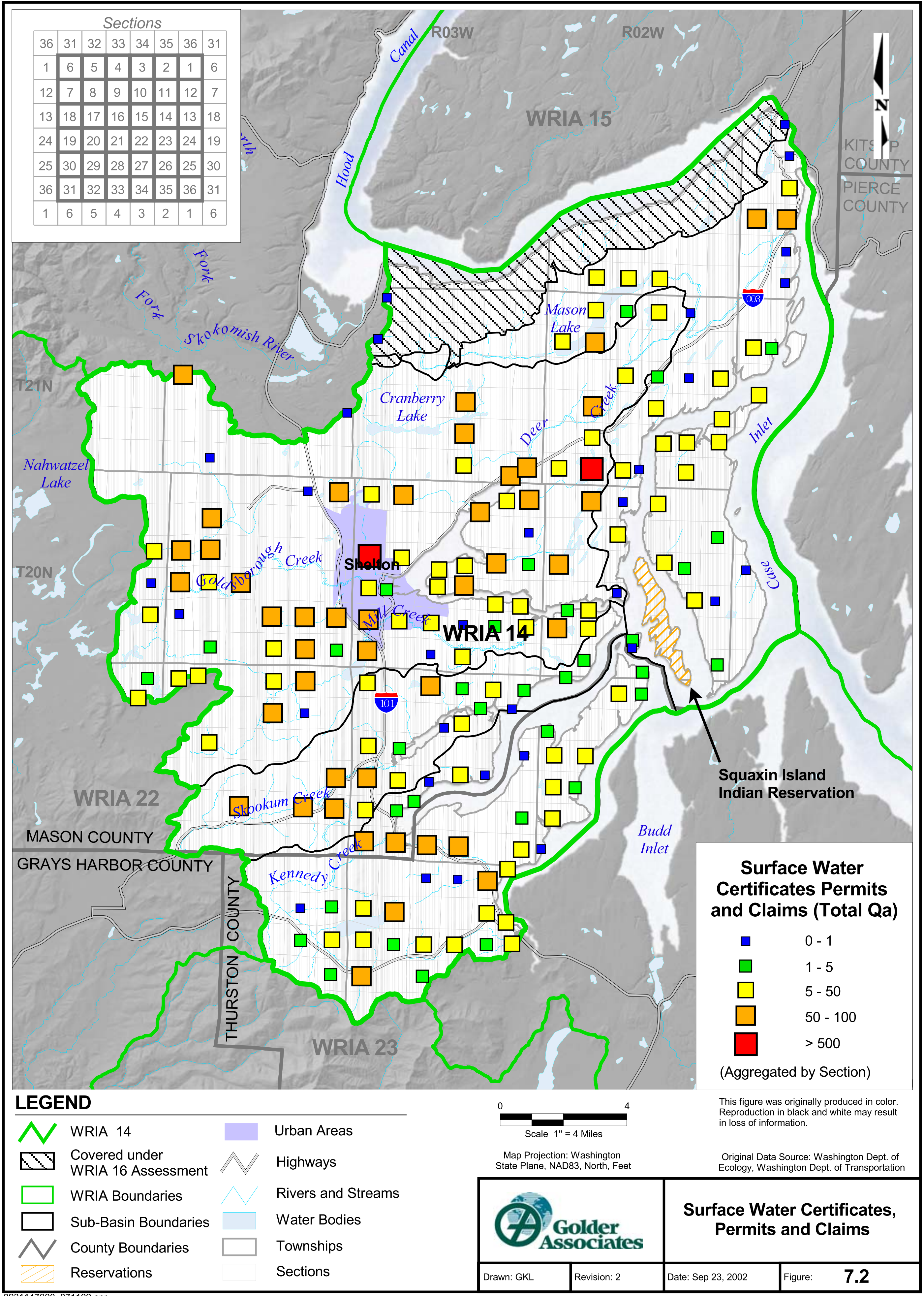
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

Golder Associates

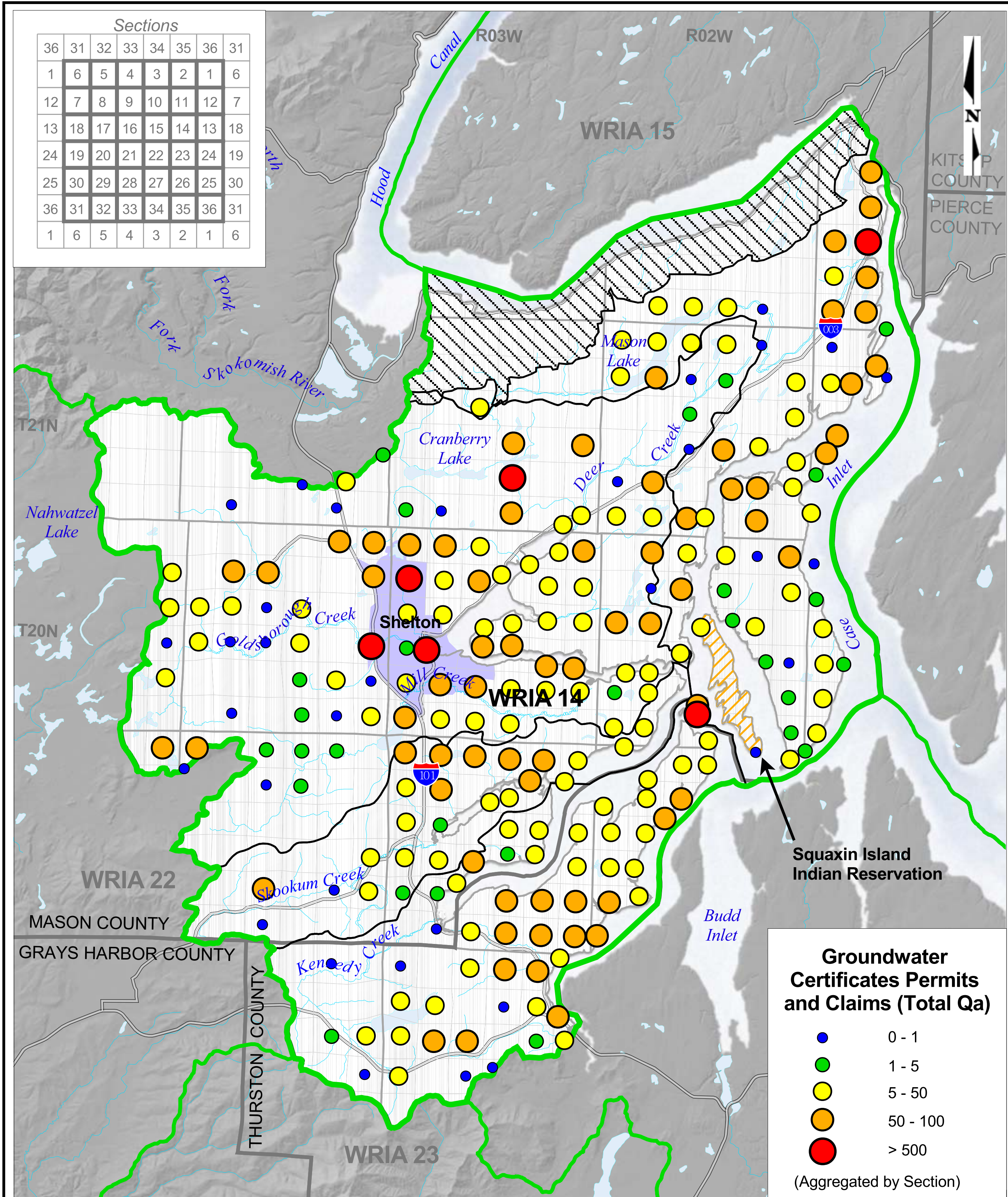
Kennedy Goldsborough Water Rights Analysis Potential Artifacts

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 7.1

0231147000_071102.apr



Sections
36 31 32 33 34 35 36 31
1 6 5 4 3 2 1 6
12 7 8 9 10 11 12 7
13 18 17 16 15 14 13 18
24 19 20 21 22 23 24 19
25 30 29 28 27 26 25 30
36 31 32 33 34 35 36 31
1 6 5 4 3 2 1 6
R03W
R02W
Hood Canal
WRIA 15
KITSAP COUNTY
PIERCE COUNTY
T21N
T20N
Skokomish River
Fork
Nahwatzel Lake
Mason Lake
Cranberry Lake
Deer Creek
Case Inlet
Goldsborough Creek
Shelton
Mill Creek
WRIA 14
Skookum Creek
Kennedy Creek
Budd Inlet
Squaxin Island Indian Reservation
WRIA 22
MASON COUNTY
GRAYS HARBOR COUNTY
THURSTON COUNTY
WRIA 23
003
101
Surface Water Certificates Permits and Claims (Total Qa)
0 - 1
1 - 5
5 - 50
50 - 100
> 500
(Aggregated by Section)
LEGEND
WRIA 14
Covered under WRIA 16 Assessment
WRIA Boundaries
Sub-Basin Boundaries
County Boundaries
Reservations
Urban Areas
Highways
Rivers and Streams
Water Bodies
Townships
Sections
0 4
Scale 1" = 4 Miles
Map Projection: Washington State Plane, NAD83, North, Feet
This figure was originally produced in color. Reproduction in black and white may result in loss of information.
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation
Golder Associates
Surface Water Certificates, Permits and Claims
Drawn: GKL
Revision: 2
Date: Sep 23, 2002
Figure: 7.2
0231147000_071102.apr



LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- Sub-Basin Boundaries
- County Boundaries
- Reservations
- Urban Areas
- Highways
- Rivers and Streams
- Water Bodies
- Townships
- Sections

0 4

Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

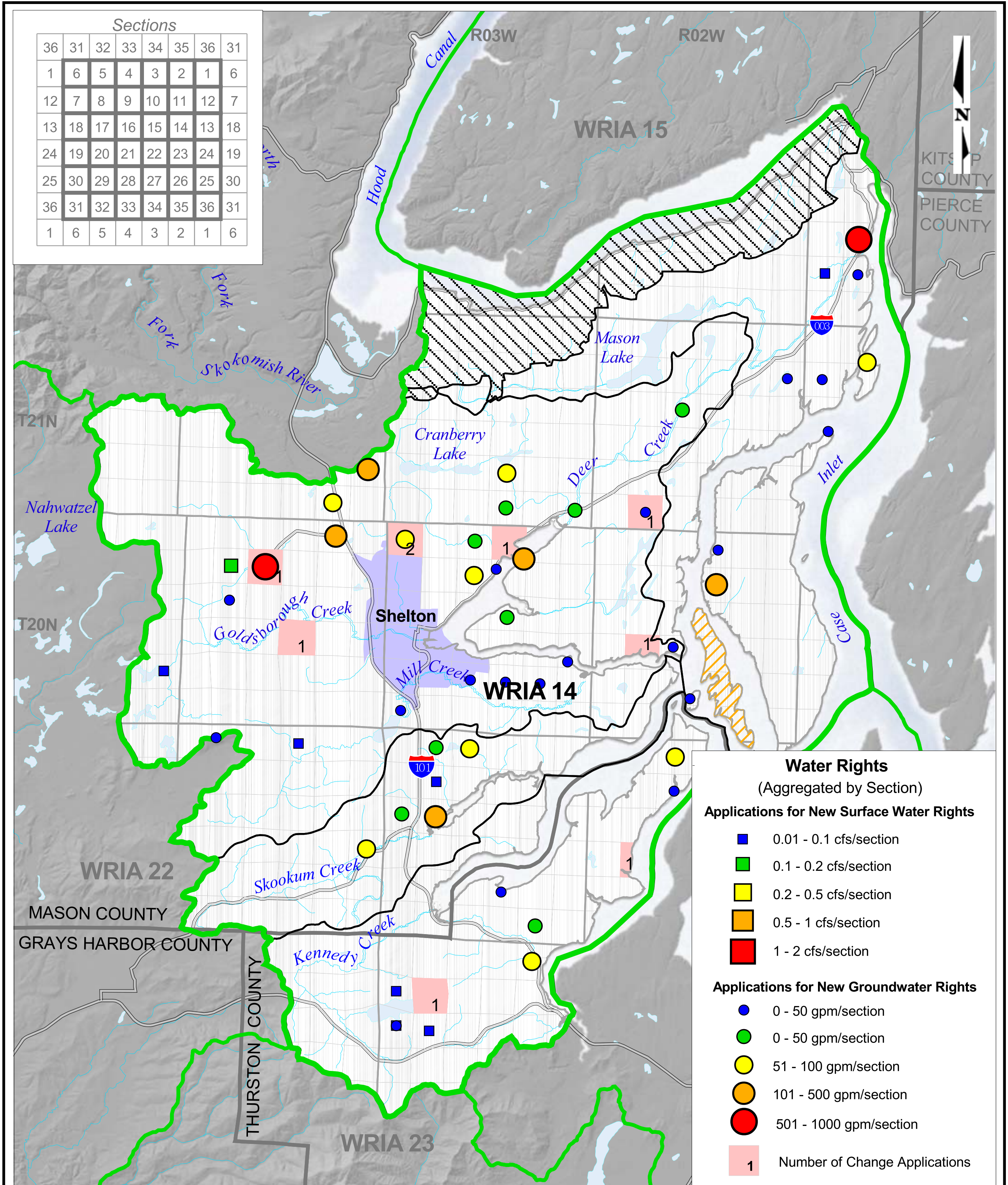
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

Golder Associates

Groundwater Certificates, Permits and Claims

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 7.3

0231147000_071102.apr



LEGEND

WRIA 14

Covered under WRIA 16 Assessment

WRIA Boundaries

Sub-Basin Boundaries

County Boundaries

Reservations

Urban Areas

Highways

Rivers and Streams

Water Bodies

Townships

Sections

0 4

Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

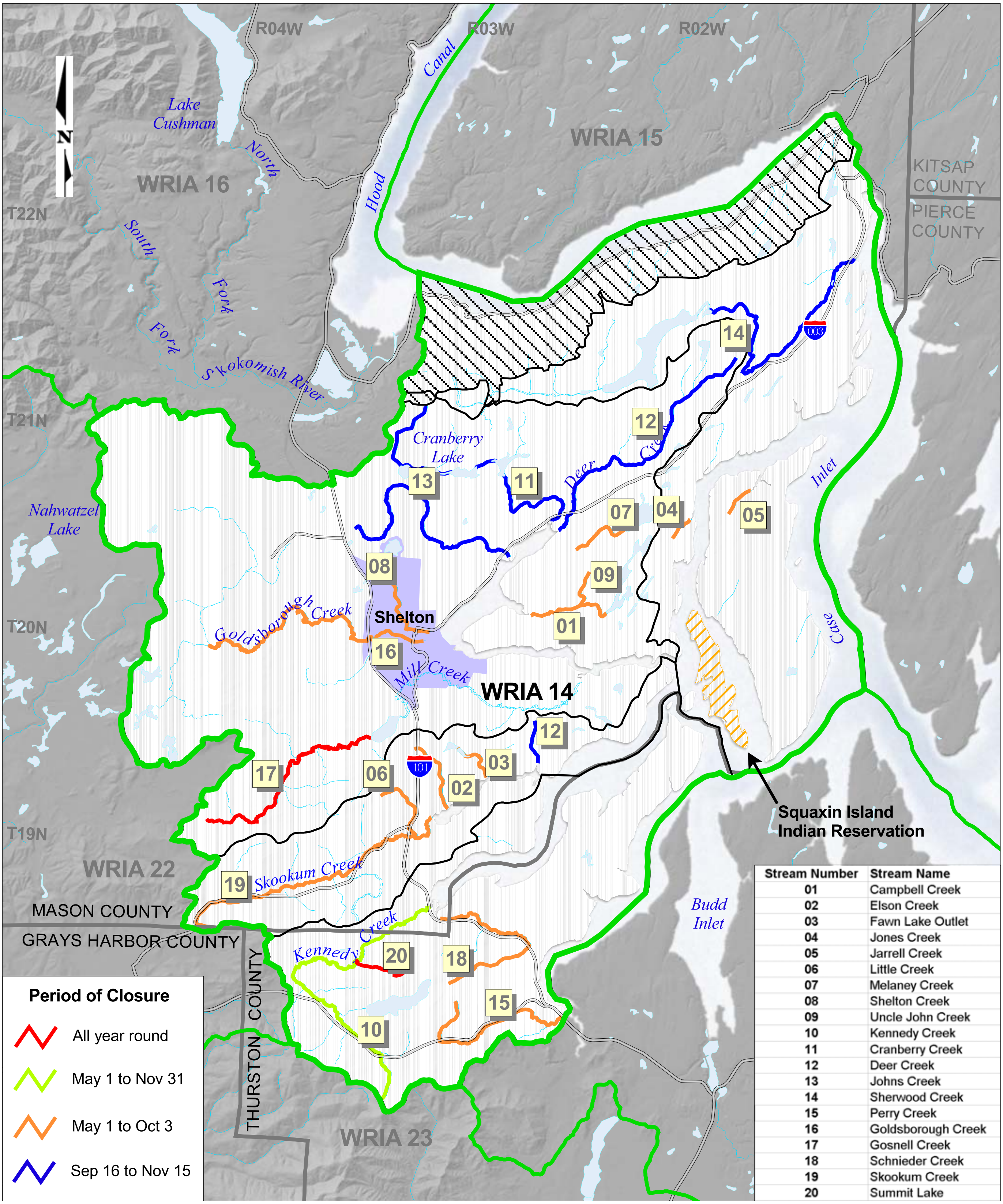
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

Golder Associates

Applications for New Water Rights and Change Applications

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 7.4

0231147000_071102.apr



Stream Number	Stream Name
01	Campbell Creek
02	Elson Creek
03	Fawn Lake Outlet
04	Jones Creek
05	Jarrell Creek
06	Little Creek
07	Melaney Creek
08	Shelton Creek
09	Uncle John Creek
10	Kennedy Creek
11	Cranberry Creek
12	Deer Creek
13	Johns Creek
14	Sherwood Creek
15	Perry Creek
16	Goldsborough Creek
17	Gosnell Creek
18	Schnieder Creek
19	Skookum Creek
20	Summit Lake

LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- Sub-Basin Boundaries
- County Boundaries
- Reservations
- Highways
- Rivers and Streams
- Water Bodies

0 4

Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

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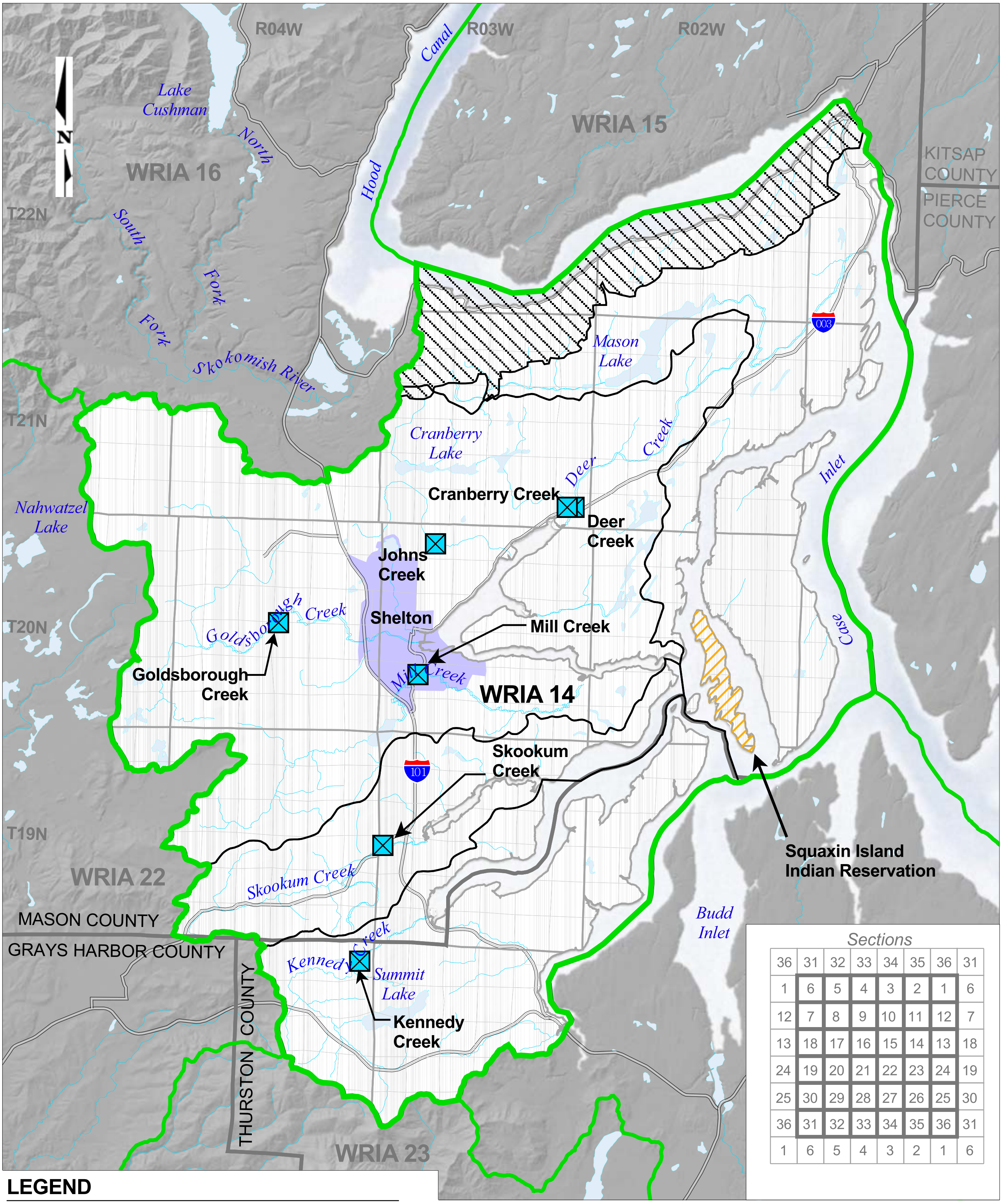
Stream Closures

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 7.5



LEGEND

- Minimum Instream Flow Control Points
- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- Sub-Basin Boundaries
- County Boundaries
- Reservations
- Urban Areas
- Highways
- Rivers and Streams
- Water Bodies
- Townships
- Sections

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

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Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

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Minimum Instream Flow Control Points

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 7.6

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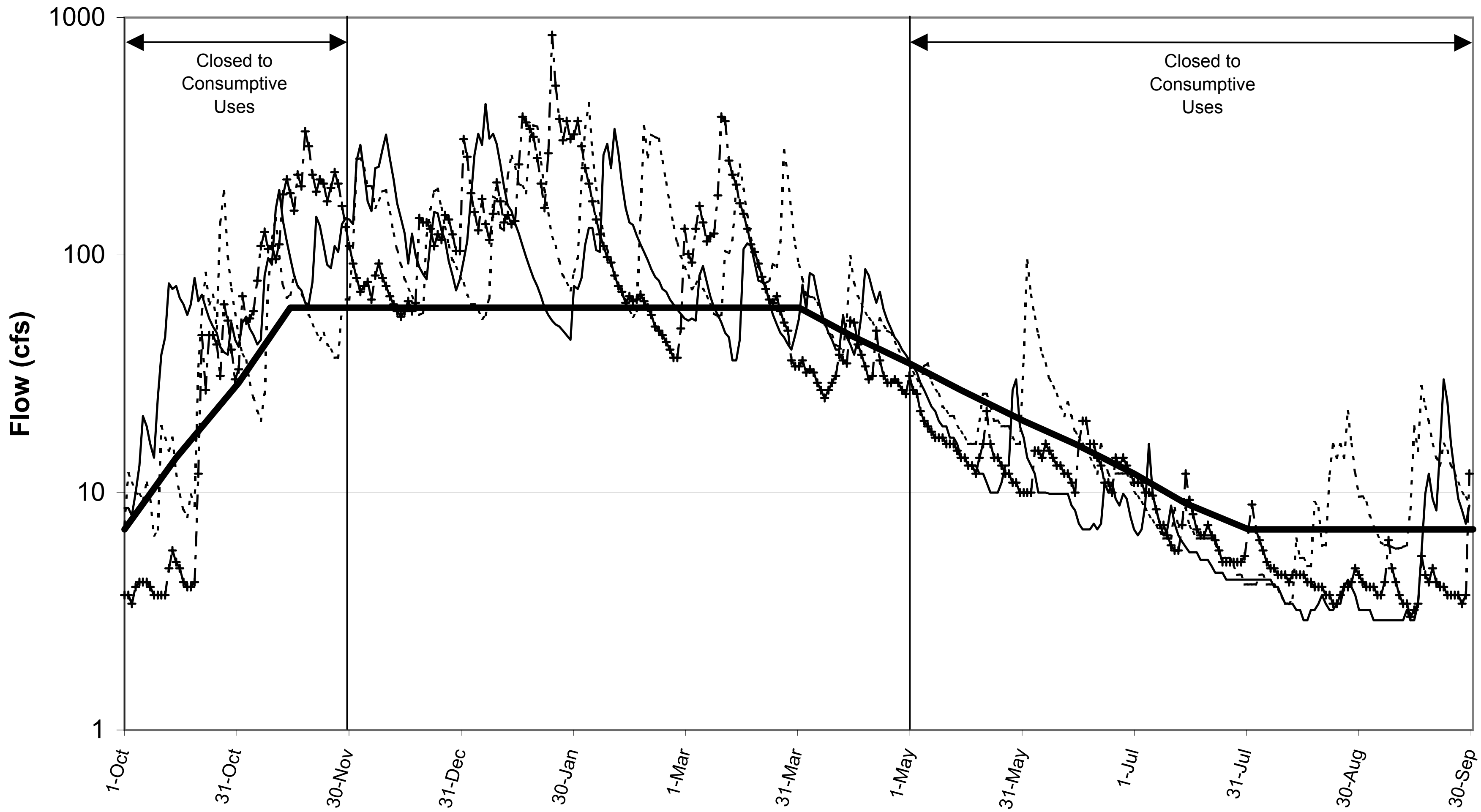


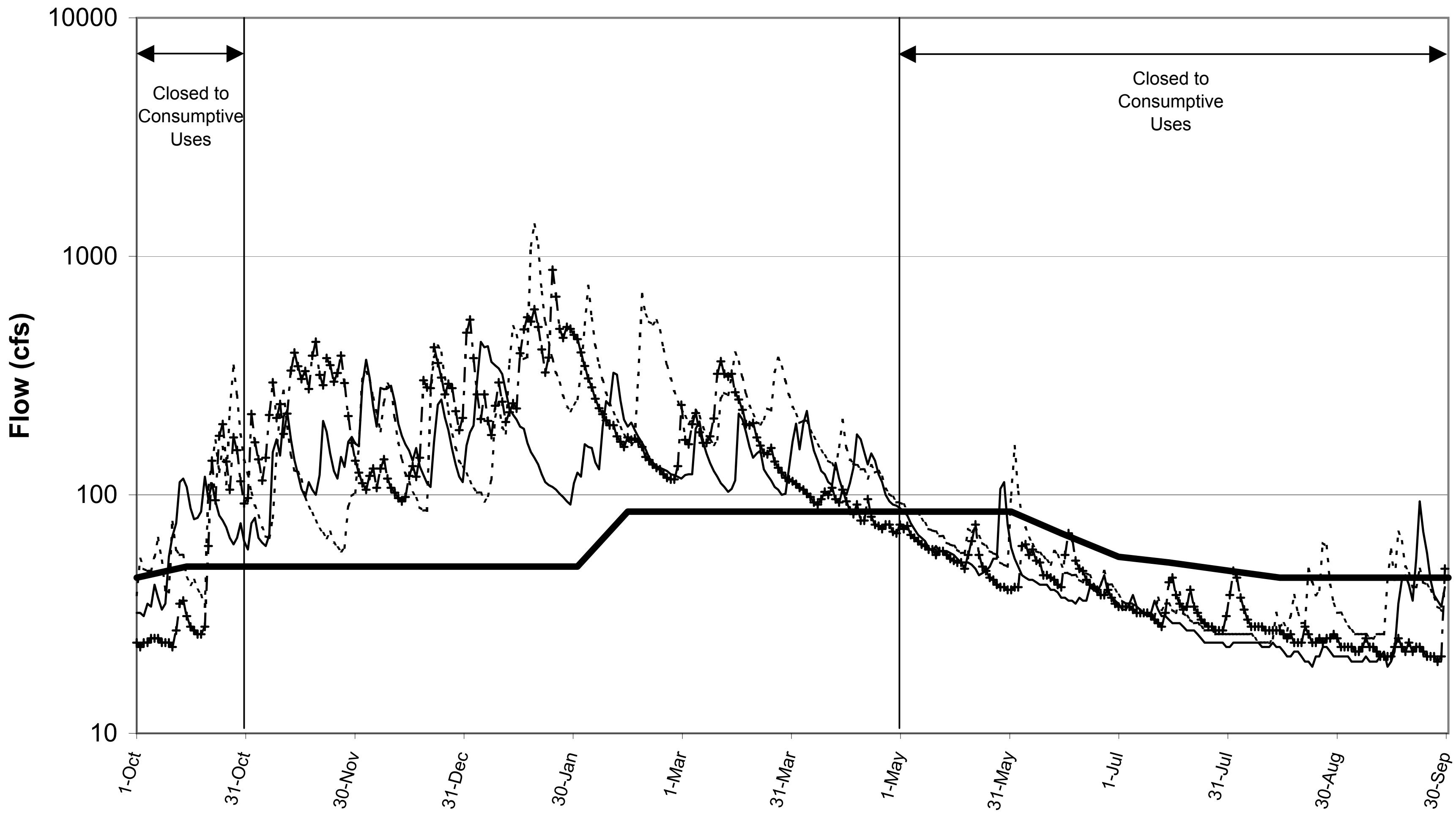
Legend

- Wet Year Flow (WY 1968)
- Average Year Flow (WY 1969)
- Dry Year Flow (WY 1964)
- Instream Flow Requirements

FIGURE 7.7: Kennedy Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



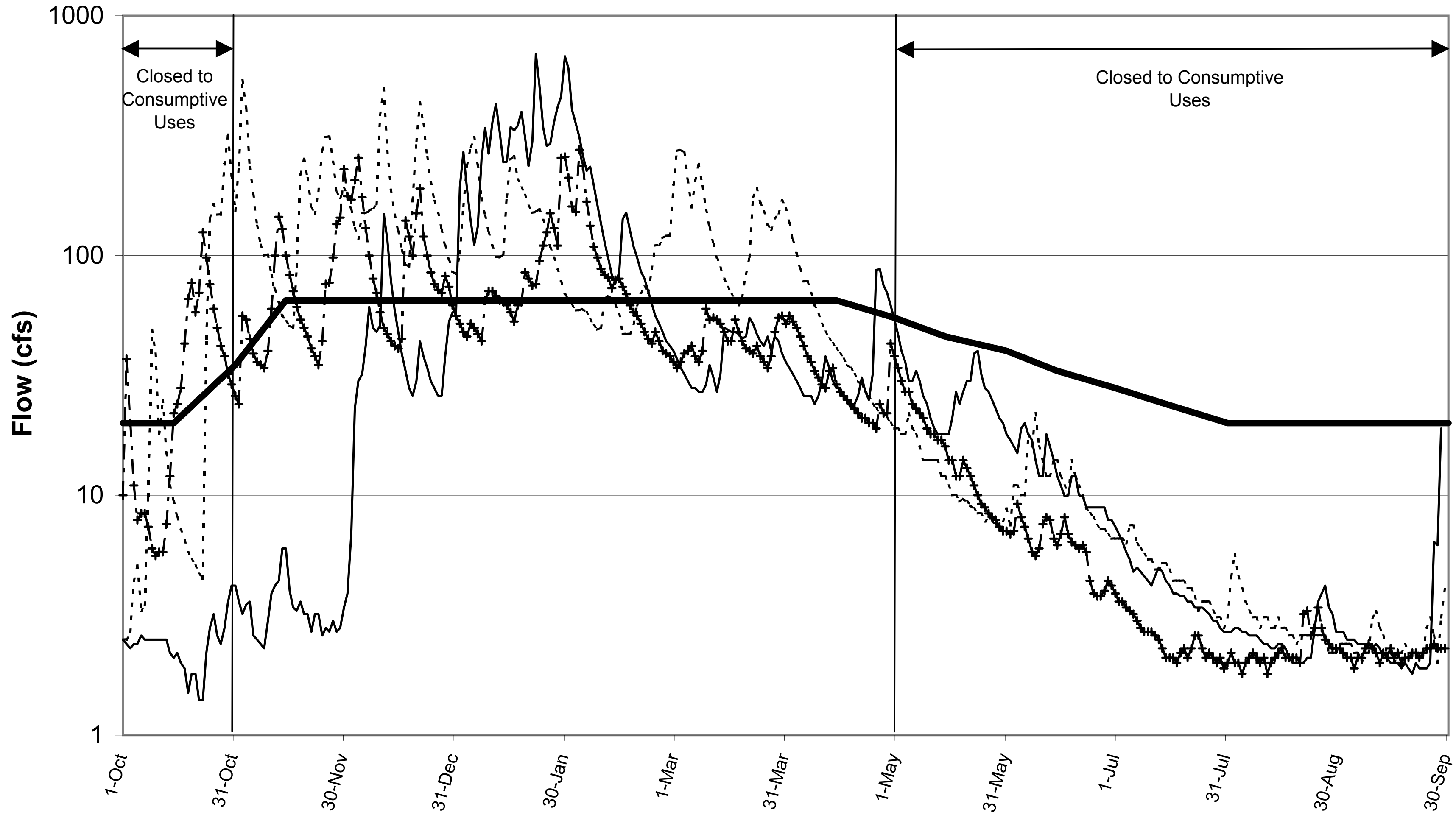
Legend

- Wet Year Flow (WY 1968)
- Average Year Flow (WY 1969)
- Dry Year Flow (WY 1964)
- Instream Flow Requirements

FIGURE 7.8: Goldsborough Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



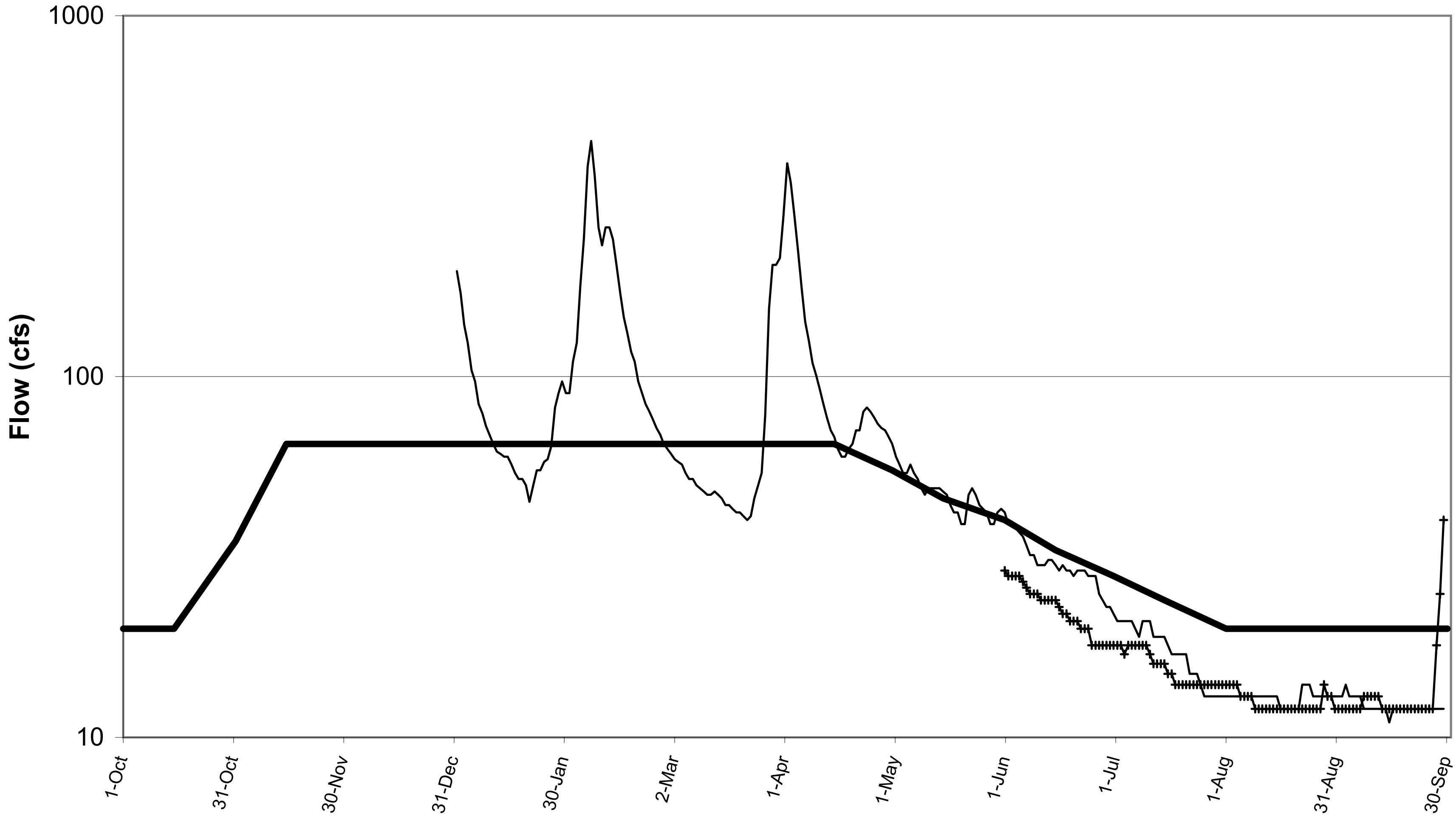
Legend

- Wet Year Flow (WY 1956)
- Average Year Flow (WY 1953)
- Dry Year Flow (WY 1952)
- Instream Flow Requirements

FIGURE 7.9: Skookum Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



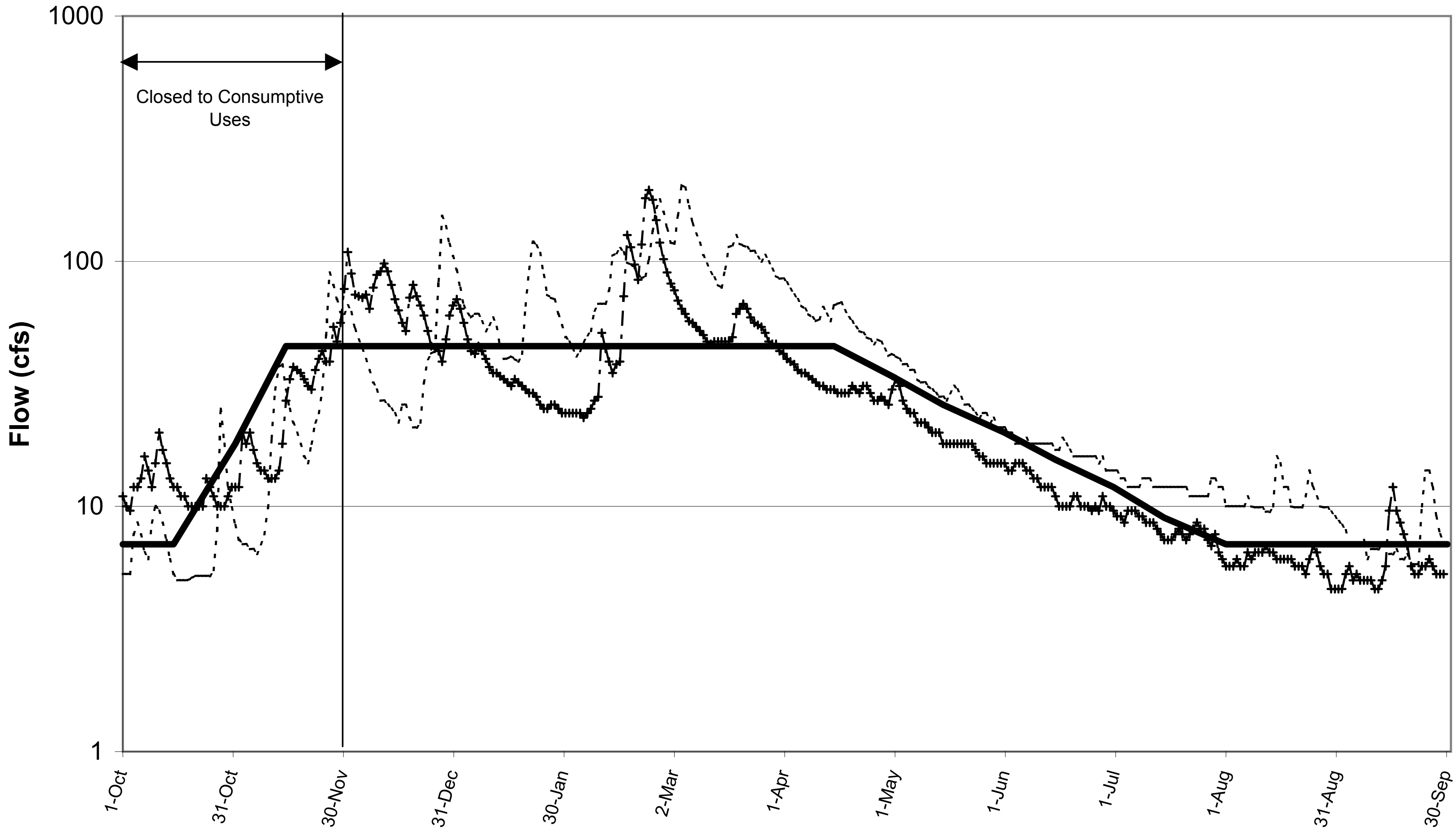
Legend

WY 1943 (Partial)
WY 1951 (Partial)
Instream Flow Requirements

FIGURE 7.10: Mill Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



Legend

Wet Year Flow (WY 1950)
Dry Year Flow (WY 1949)
Instream Flow Requirements

FIGURE 7.11: Johns Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

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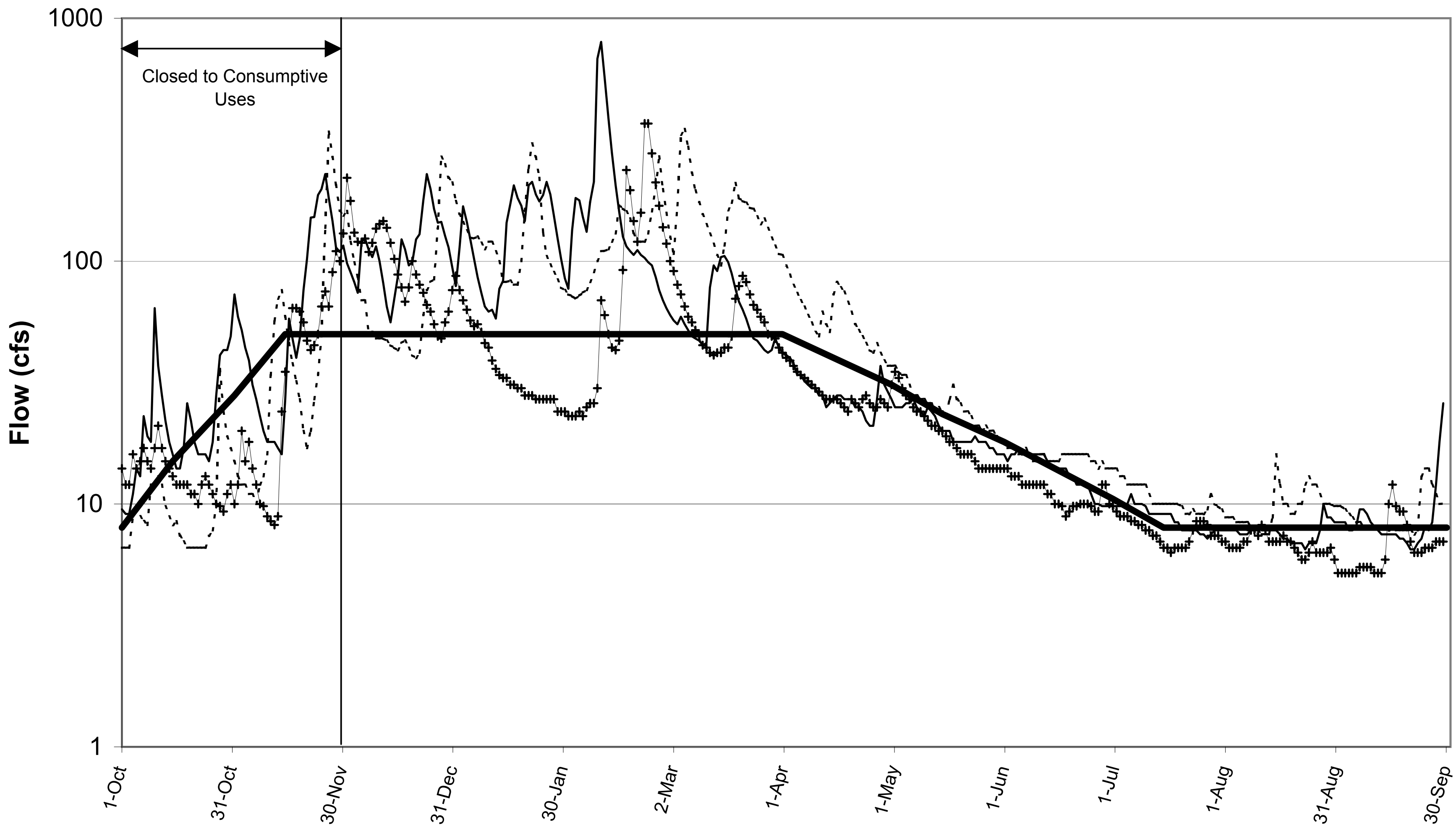


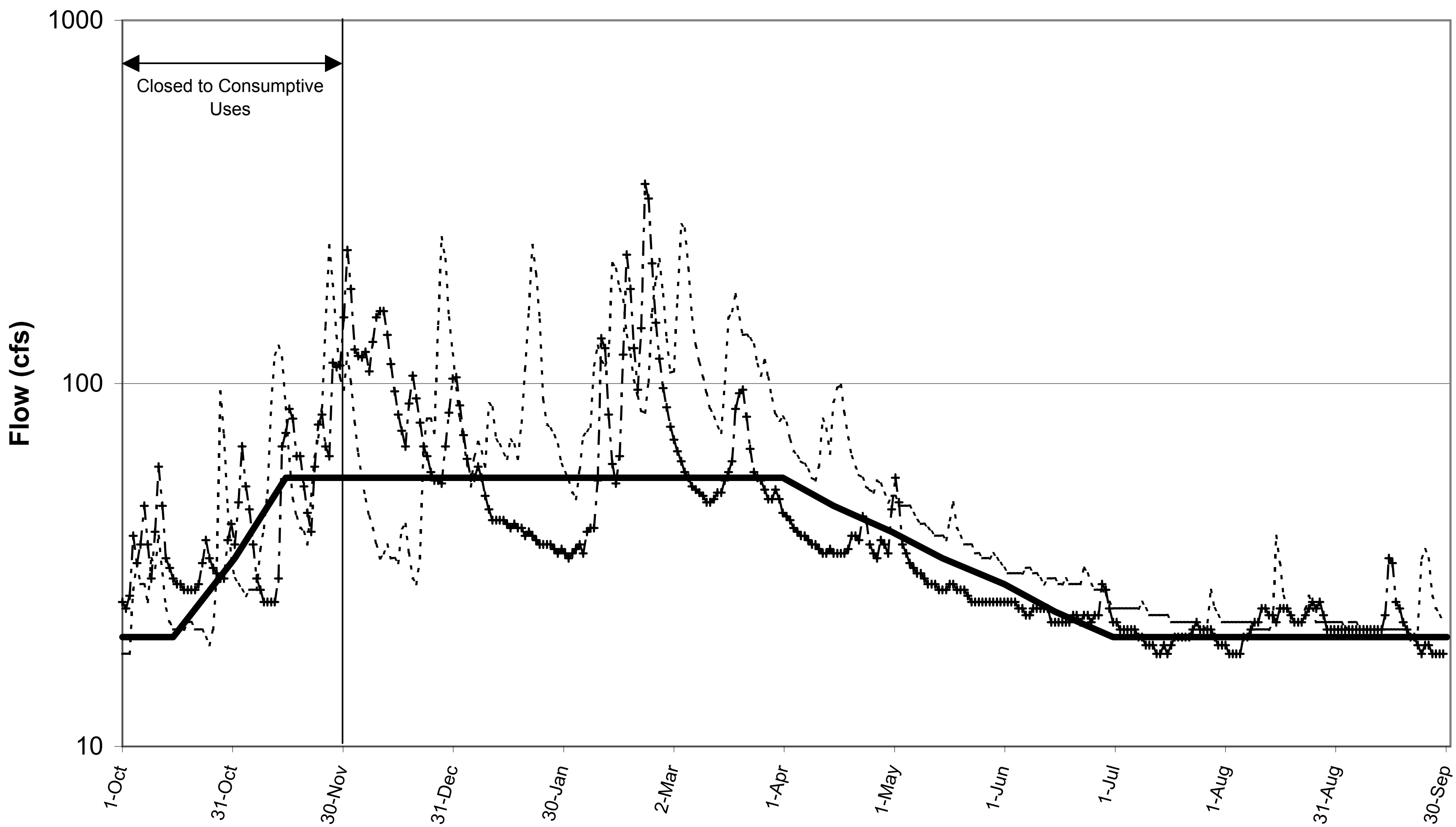
Legend

- Wet Year Flow (WY 1956)
- Average Year Flow (WY 1953)
- Dry Year Flow (WY 1952)
- Instream Flow Requirements

FIGURE 7.12: Cranberry Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates



Legend

- Wet Year Flow (WY 1950)
- Dry Year Flow (WY 1949)
- Instream Flow Requirement

FIGURE 7.13: Deer Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

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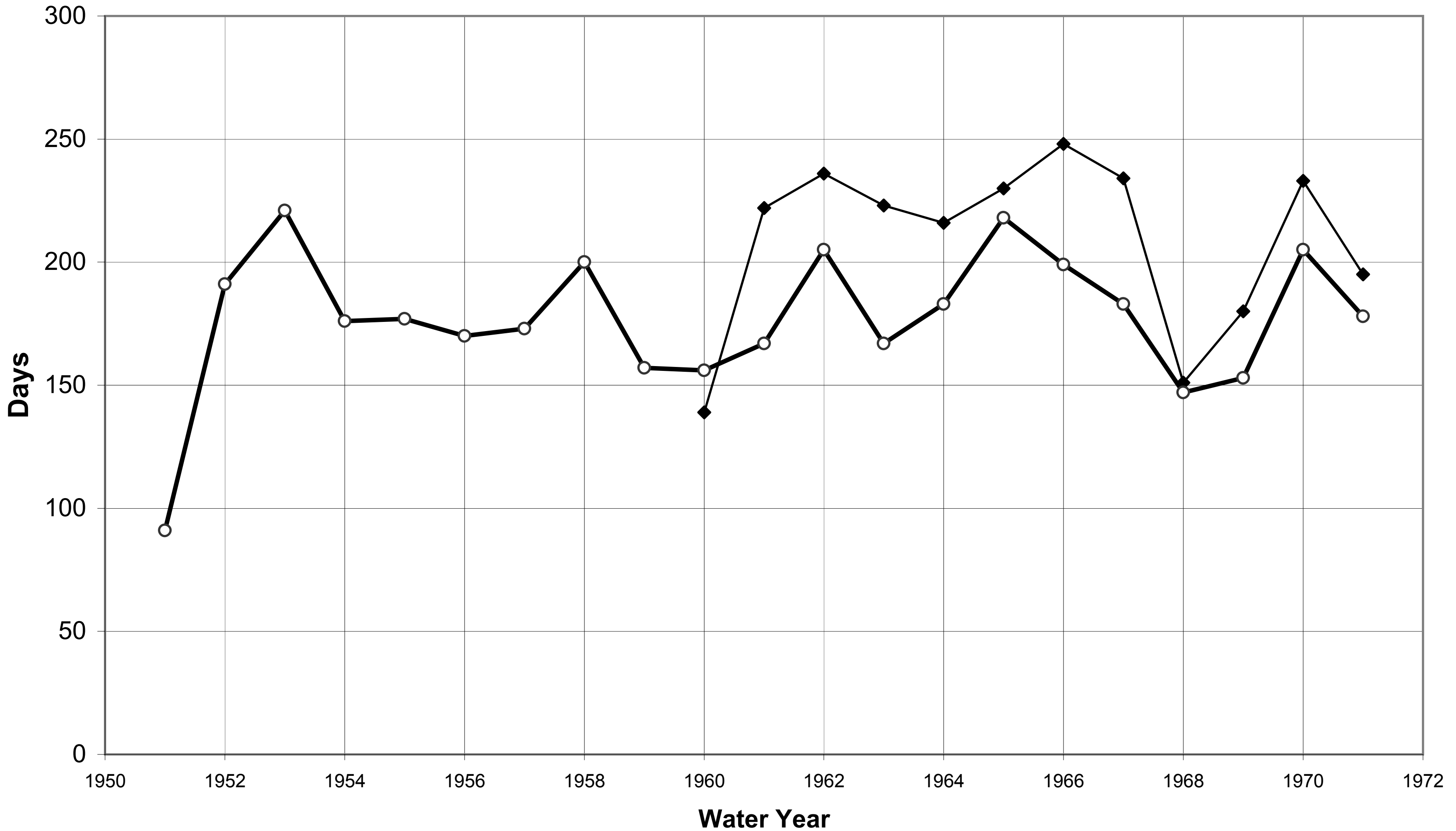

Legend

Kennedy Creek Near Kamilche, WA

Goldsborough Creek Near Shelton, WA

FIGURE 7.14: Number of Days Annually that Instream Flows are Not Met.

WRIA 14 Planning Unit
Level 1 Assessment

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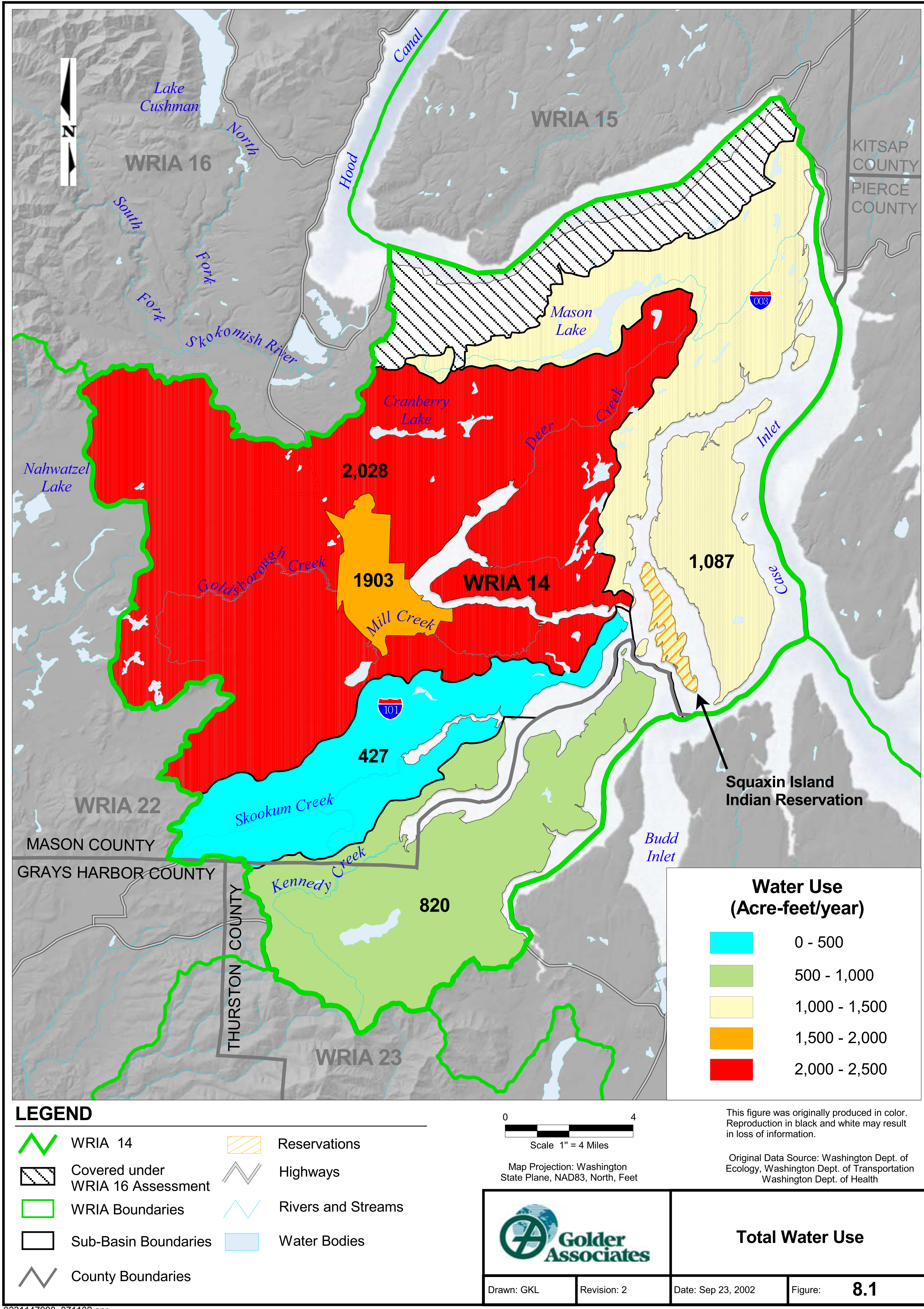

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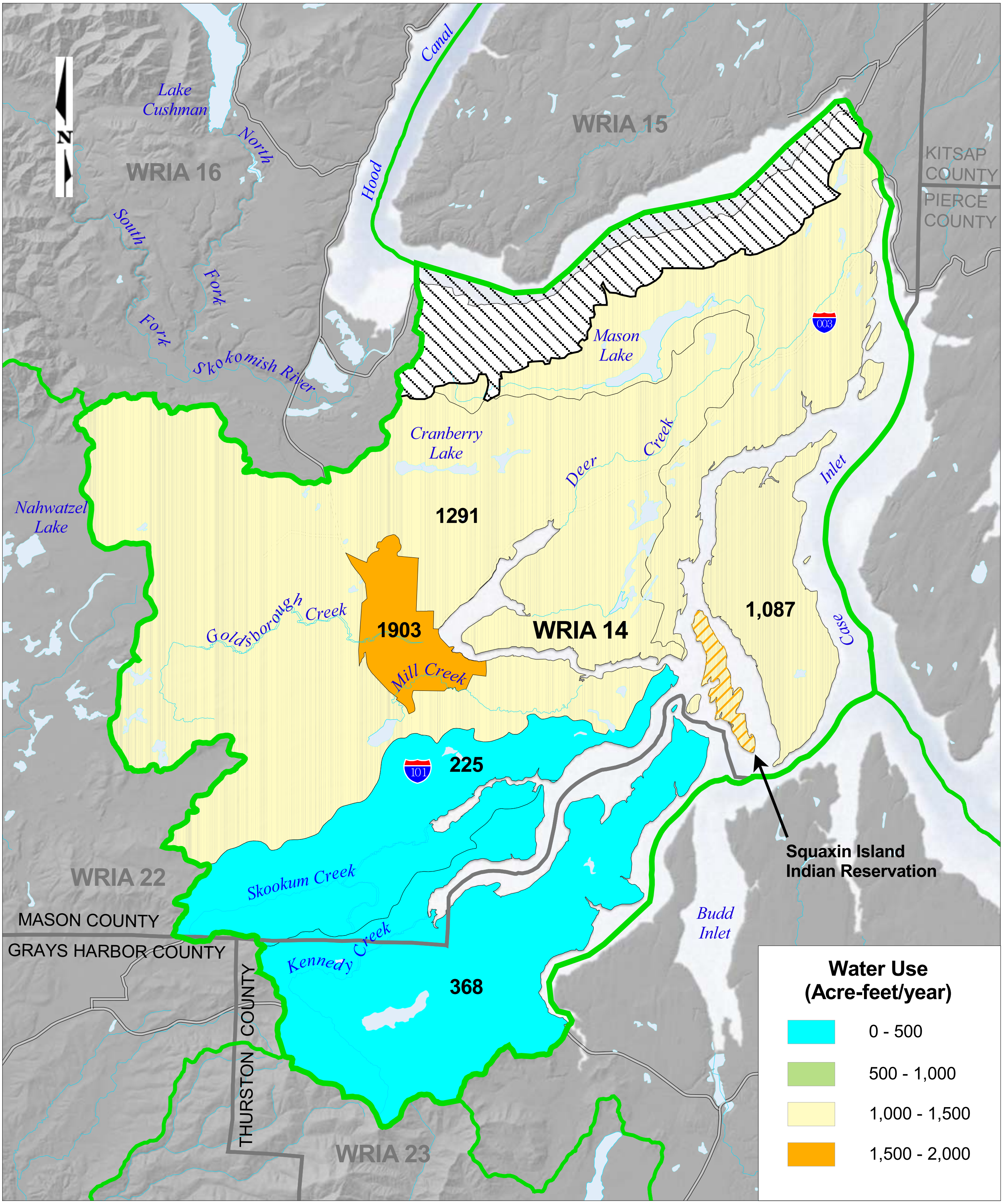

LEGEND

WRIA 14	Reservations
Covered under WRIA 16 Assessment	Highways
WRIA Boundaries	Rivers and Streams
Sub-Basin Boundaries	Water Bodies
County Boundaries	

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

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Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation Washington Dept. of Health

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Purveyor Water Use

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 8.2

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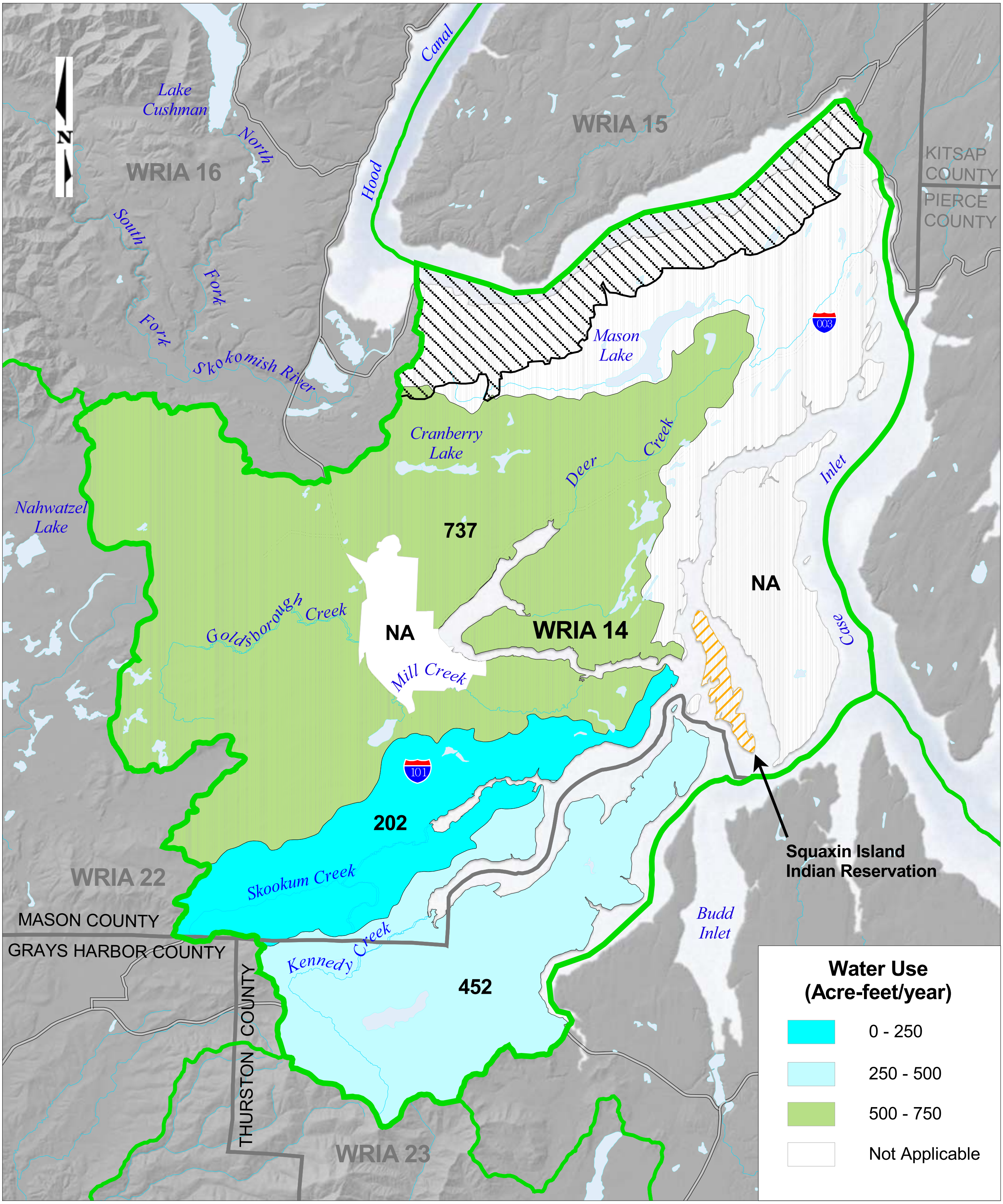


LEGEND

WRIA 14	Reservations
Covered under WRIA 16 Assessment	Highways
WRIA Boundaries	Rivers and Streams
Sub-Basin Boundaries	Water Bodies
County Boundaries	

0 4

Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

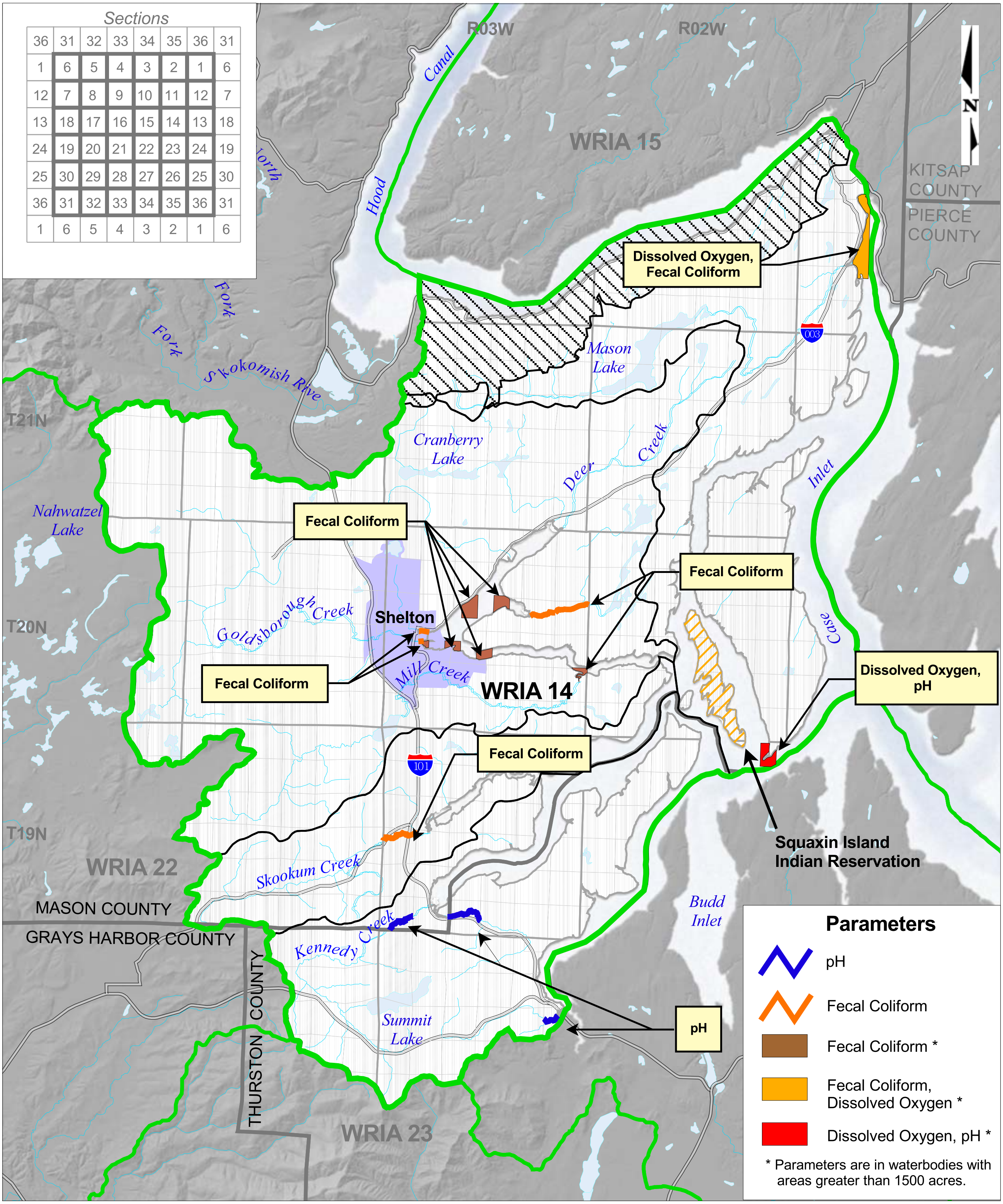
Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation Washington Dept. of Health

Golder Associates

Exempt Well Water Use

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 8.3

0231147000_071102.apr



LEGEND

- WRIA 14
- Covered under WRIA 16 Assessment
- WRIA Boundaries
- Sub-Basin Boundaries
- County Boundaries
- Reservations
- Urban Areas
- Highways
- Rivers and Streams
- Water Bodies
- Townships
- Sections

0 4
Scale 1" = 4 Miles

Map Projection: Washington State Plane, NAD83, North, Feet

This figure was originally produced in color. Reproduction in black and white may result in loss of information.

Original Data Source: Washington Dept. of Ecology, Washington Dept. of Transportation

Golder Associates

1998 303(d) Listed Impaired Water Quality Waterbodies

Drawn: GKL	Revision: 2	Date: Sep 23, 2002	Figure: 9.1

0231147000_071102.apr

APPENDIX A

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Table A-1
Water Balance for Upper Goldsbrough Catchment (Predominently Sediments)

Month	Precipitation[1]	AET Blaney Criddle (in)	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
October	13,692	0.7	1,605	2,922	7,789	1,377	3,840	3,949	4,298	0%
November	25,475	1.4	3,016	6,264	14,818	1,377	3,840	10,978	7,640	0%
December	26,914	1.0	2,215	10,768	12,554	1,377	3,840	8,714	12,145	0%
January	25,898	1.1	2,268	11,389	10,864	1,377	3,840	7,024	12,766	0%
February	20,098	1.3	2,702	8,297	7,723	1,377	3,840	3,883	9,673	0%
March	17,215	2.0	4,293	7,025	4,520	1,377	3,840	680	8,402	0%
April	10,492	2.9	6,121	6,795	-3,800	1,377	3,840	-7,640	8,172	0%
May	5,947	3.5	7,556	2,531	-5,516	1,377	3,840	-9,356	3,907	0%
June	4,418	3.1	6,678	1,085	-4,722	1,377	3,840	-8,562	2,461	0%
July	2,299	1.4	3,013	432	-2,523	1,377	3,840	-6,363	1,809	0%
August	3,009	0.7	1,456	0	177	1,377	3,840	-3,663	1,377	0%
September	6,898	0.3	719	605	4,197	1,377	3,840	357	1,981	0%
Annual	162,355	19.41	41,643	58,114	46,080	16,518	46,080	0	74,632	0

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Criddle Method and a soil moisture holding capacity of 6 inches
3) Runoff = streamflow -baseflow
4) Groundwater Residual = Precipitation - Actual Evapotranspiration - Runoff - Baseflow
5) Baseflow is assumed to be constant throughout the year as is equal to the minimum monthly streamflow volume.
6) Monthly underflow = annual groundwater residual/12
7) Change in groundwater storage = groundwater residual - underflow
8) Streamflow volume is calculate using USGS daily flow data and calculated on a monthly resolution (USGS Station 12076500 Goldsborough Creek Near Shelton, WA) October 1, 1968 to September 31, 1969.
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.

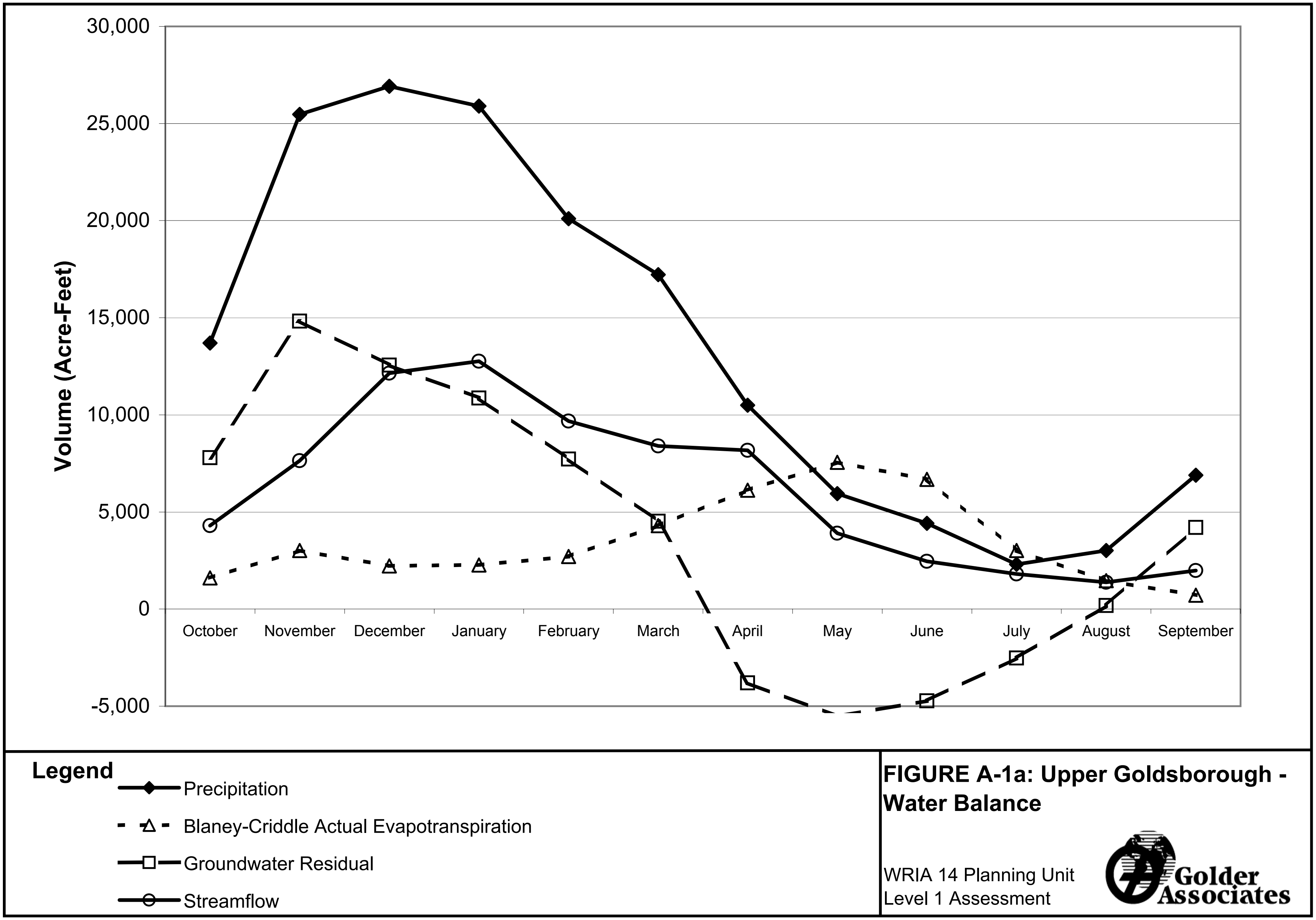

FIGURE A-1a: Upper Goldsborough - Water Balance

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Level 1 Assessment

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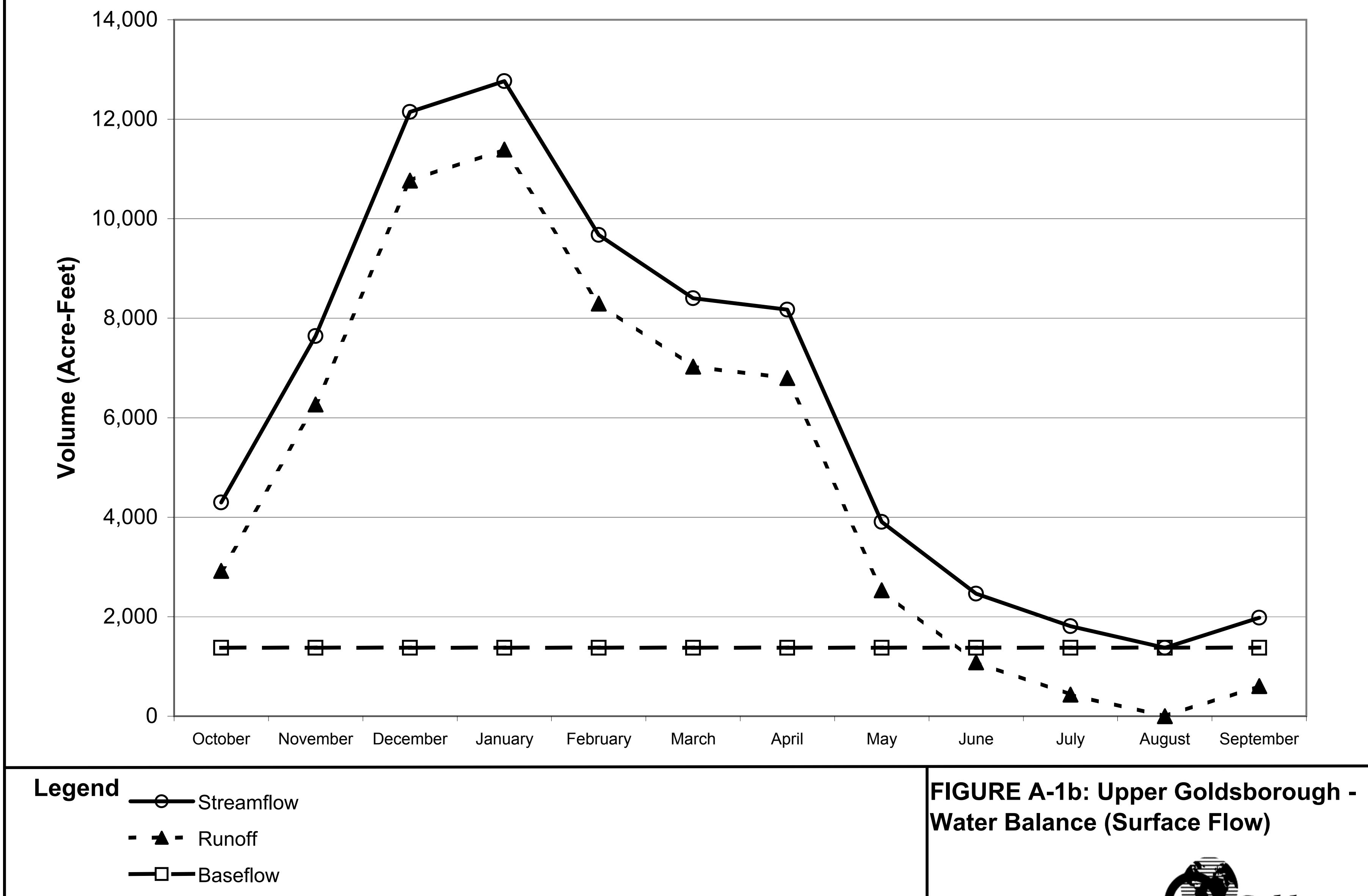

FIGURE A-1b: Upper Goldsborough - Water Balance (Surface Flow)

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Level 1 Assessment

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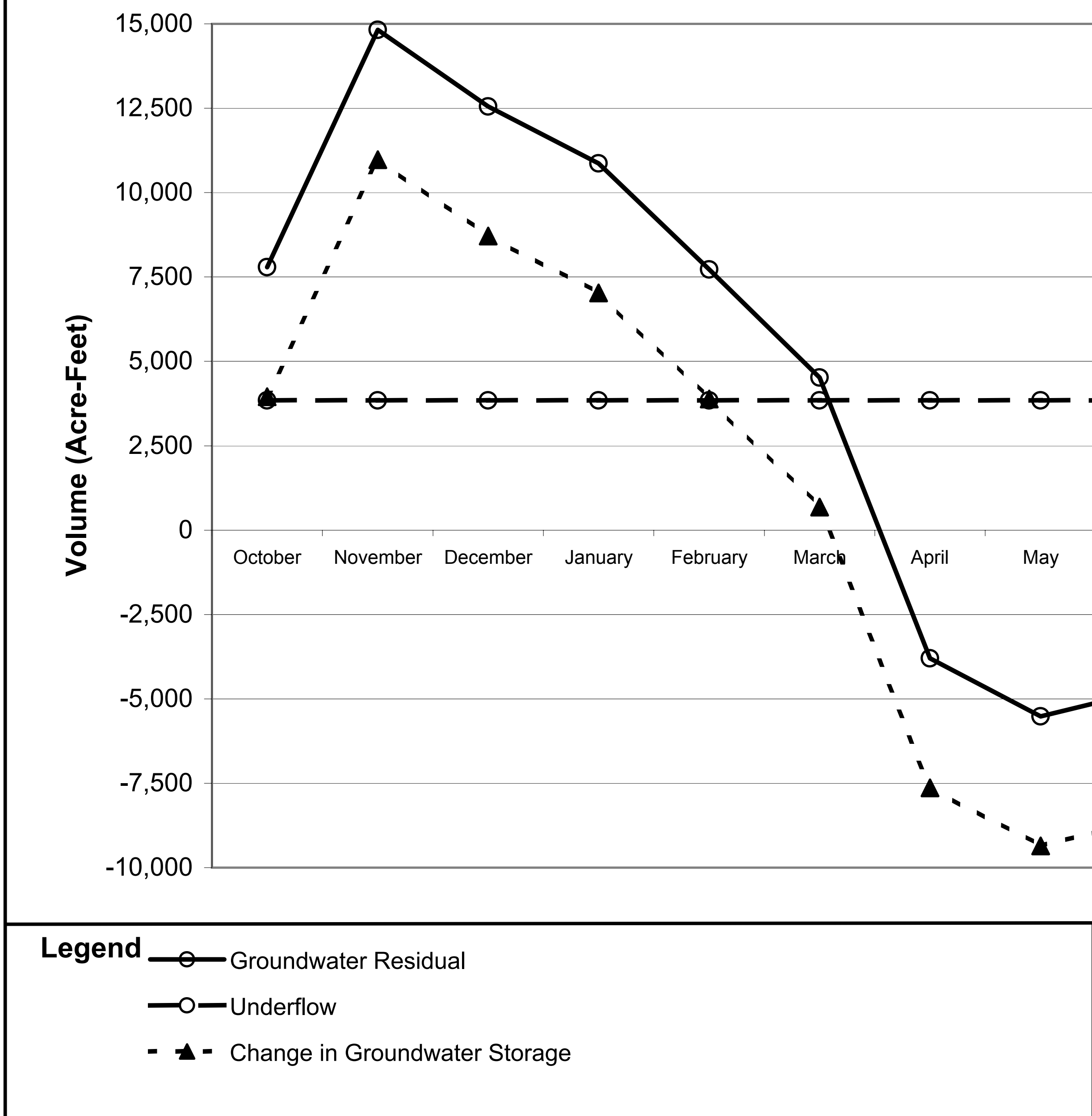


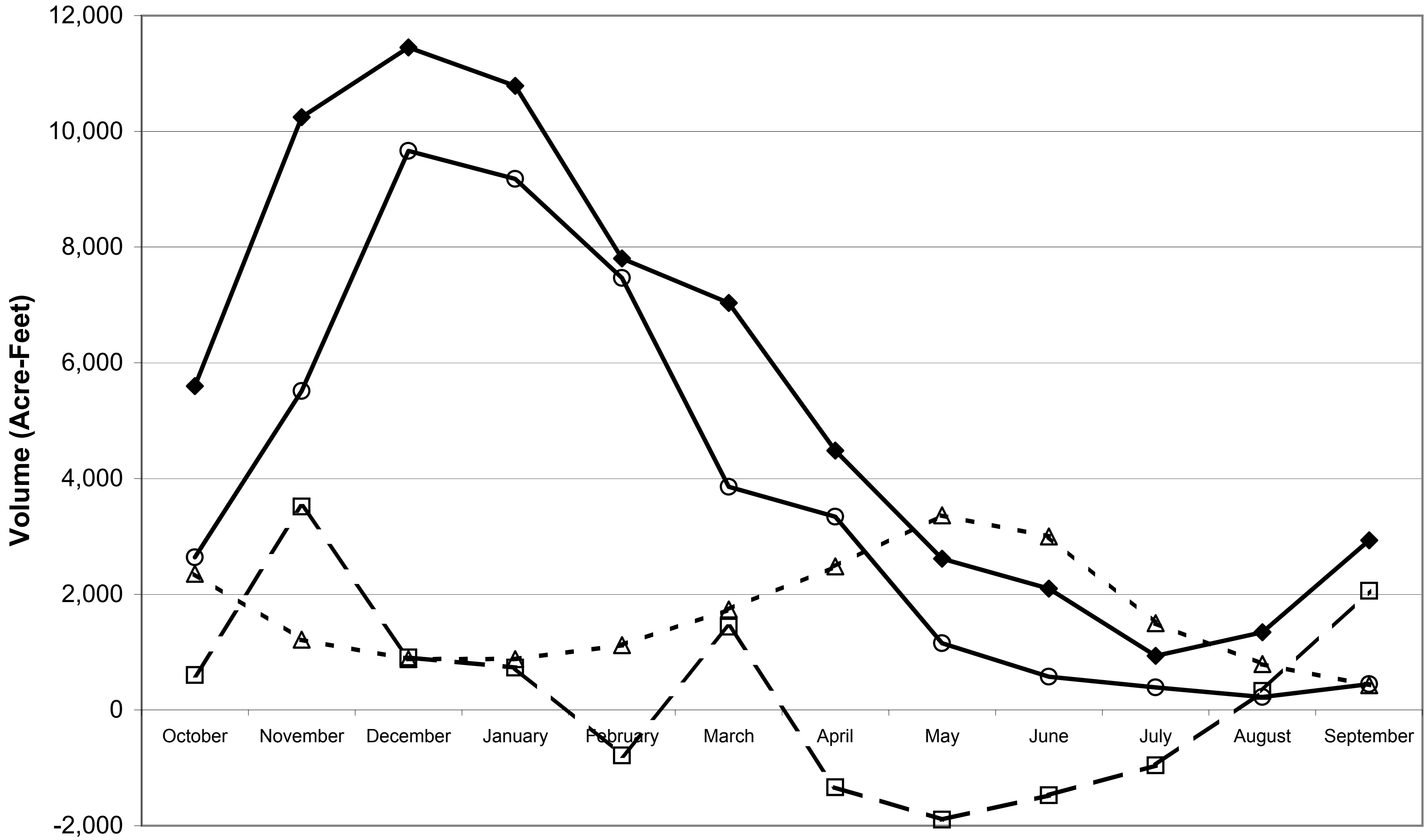
FIGURE A-1c: Upper Goldsborough - Water Balance (Groundwater)

WRIA 14 Planning Unit
Level 1 Assessment

Table A-2
Water Balance for Upper Kennedy Catchment (Predominantly Basalt)

Month	Precipitation[1]	AET Blaney Criddle (in)	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
October	5,598	2.6	2,354	2,415	604	225	261	343	2,640	0%
November	10,244	1.3	1,217	5,287	3,515	225	261	3,254	5,512	0%
December	11,449	1.0	879	9,436	909	225	261	647	9,661	0%
January	10,788	1.0	877	8,954	731	225	261	470	9,180	0%
February	7,802	1.2	1,118	7,243	-784	225	261	-1,046	7,468	0%
March	7,035	1.9	1,738	3,633	1,439	225	261	1,178	3,858	0%
April	4,483	2.7	2,480	3,117	-1,338	225	261	-1,600	3,342	0%
May	2,617	3.7	3,362	927	-1,897	225	261	-2,159	1,152	0%
June	2,098	3.3	2,996	350	-1,474	225	261	-1,735	576	0%
July	933	1.7	1,500	165	-957	225	261	-1,218	390	0%
August	1,346	0.9	794	0	326	225	261	65	225	0%
September	2,934	0.5	428	220	2,062	225	261	1,800	445	0%
Annual	67,327	21.74	19,742	41,748	3,136	2,701	3,136	0	44,449	0%

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Criddle Method and a soil moisture holding capacity of 6 inches
3) Runoff = streamflow -baseflow
4) Groundwater Residual = Precipitation - Actual Evapotranspiration - Runoff - Baseflow
5) Baseflow is assumed to be constant throughout the year as is equal to the minimum monthly streamflow volume.
6) Monthly underflow = annual groundwater residual/12
7) Change in groundwater storage = groundwater residual - underflow
8) Streamflow volume is calculate using USGS daily flow data and calculated on a monthly resolution (USGS Station 12078400 Kennedy Creek Near Kamilche, WA) October 1, 1968 to September 31, 1969.
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.



Legend

- Precipitation
- Blaney-Criddle Actual Evapotranspiration
- Groundwater Residual
- Streamflow

FIGURE A-2a: Upper Kennedy - Water Balance

WRIA 14 Planning Unit
Level 1 Assessment

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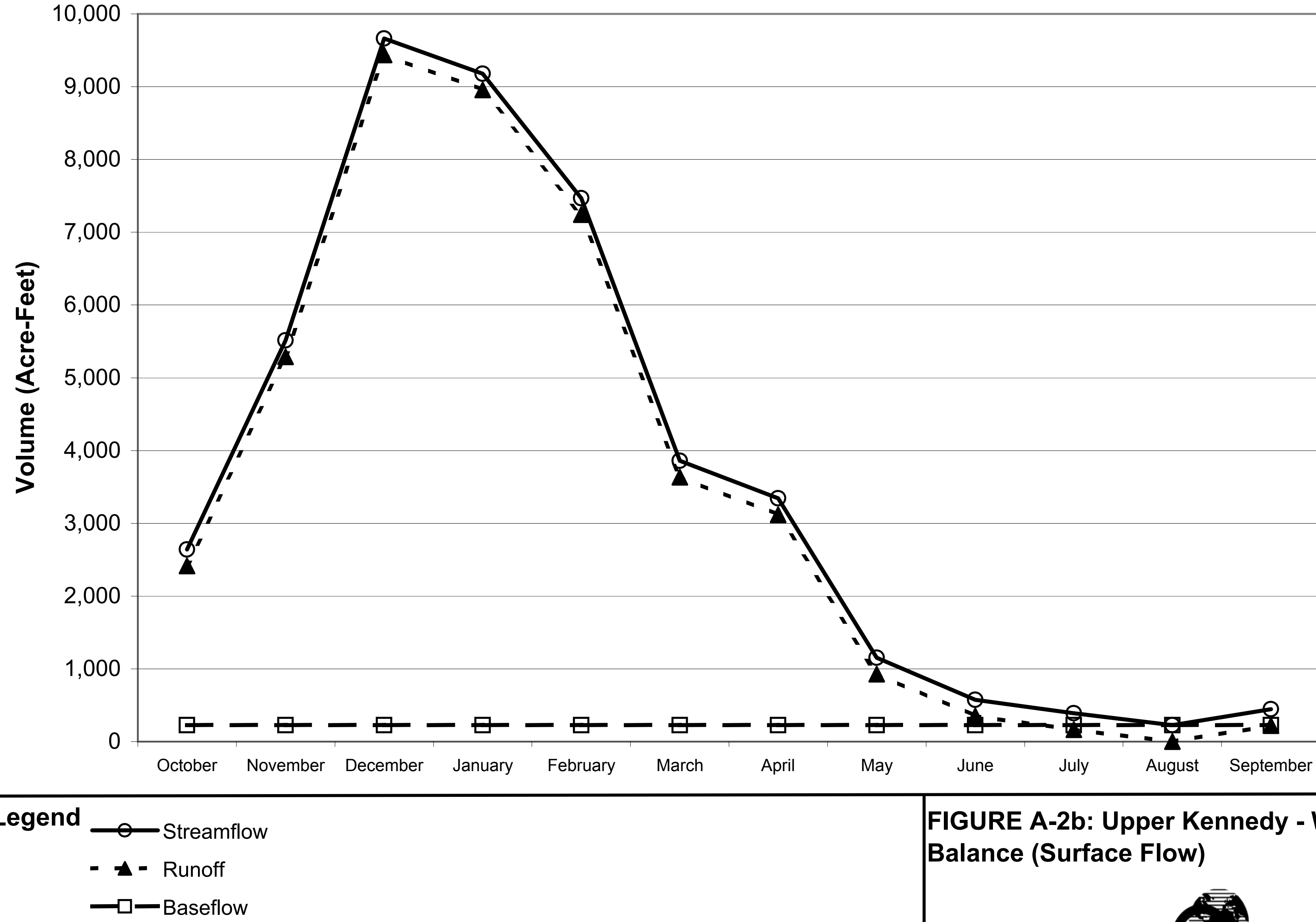

FIGURE A-2b: Upper Kennedy - Water Balance (Surface Flow)

WRIA 14 Planning Unit
Level 1 Assessment

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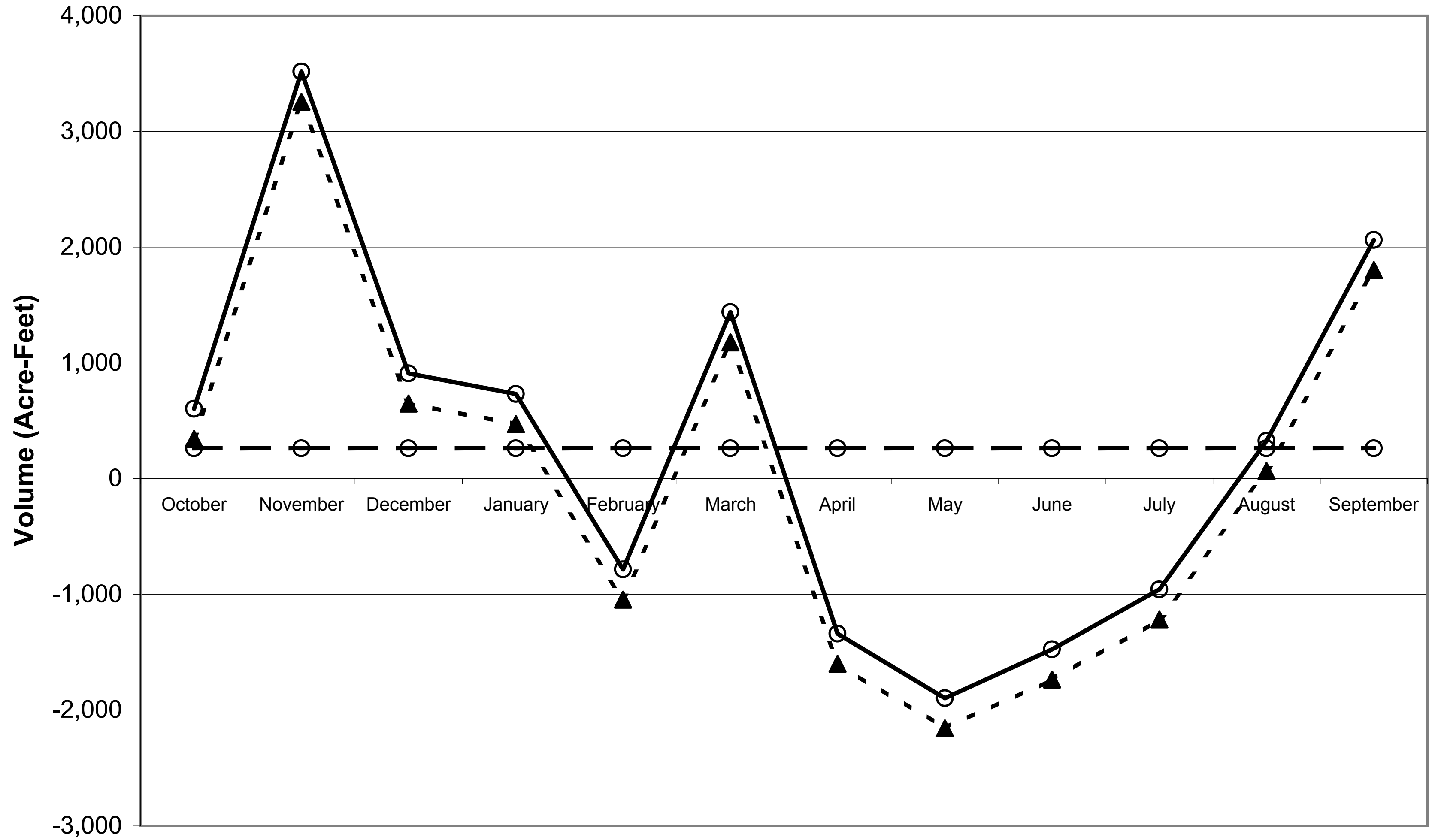

Legend
Groundwater Residual
Underflow
Change in Groundwater Storage

FIGURE A-2c: Upper Kennedy - Water Balance (Groundwater)

WRIA 14 Planning Unit
Level 1 Assessment

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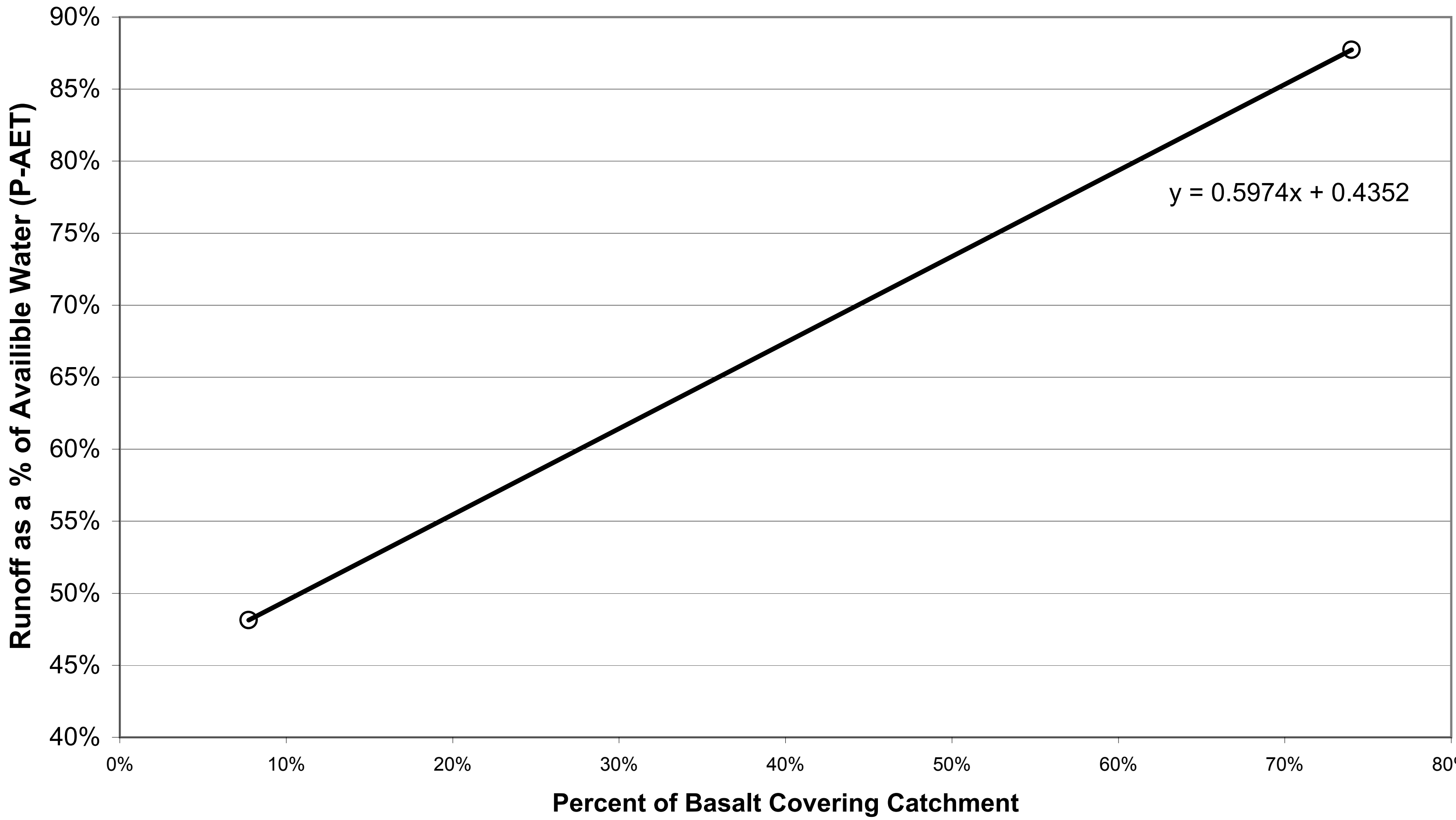

Legend

FIGURE A-3: Annual Runoff as a Percentage of Available Water

WRIA 14 Planning Unit
Level 1 Assessment

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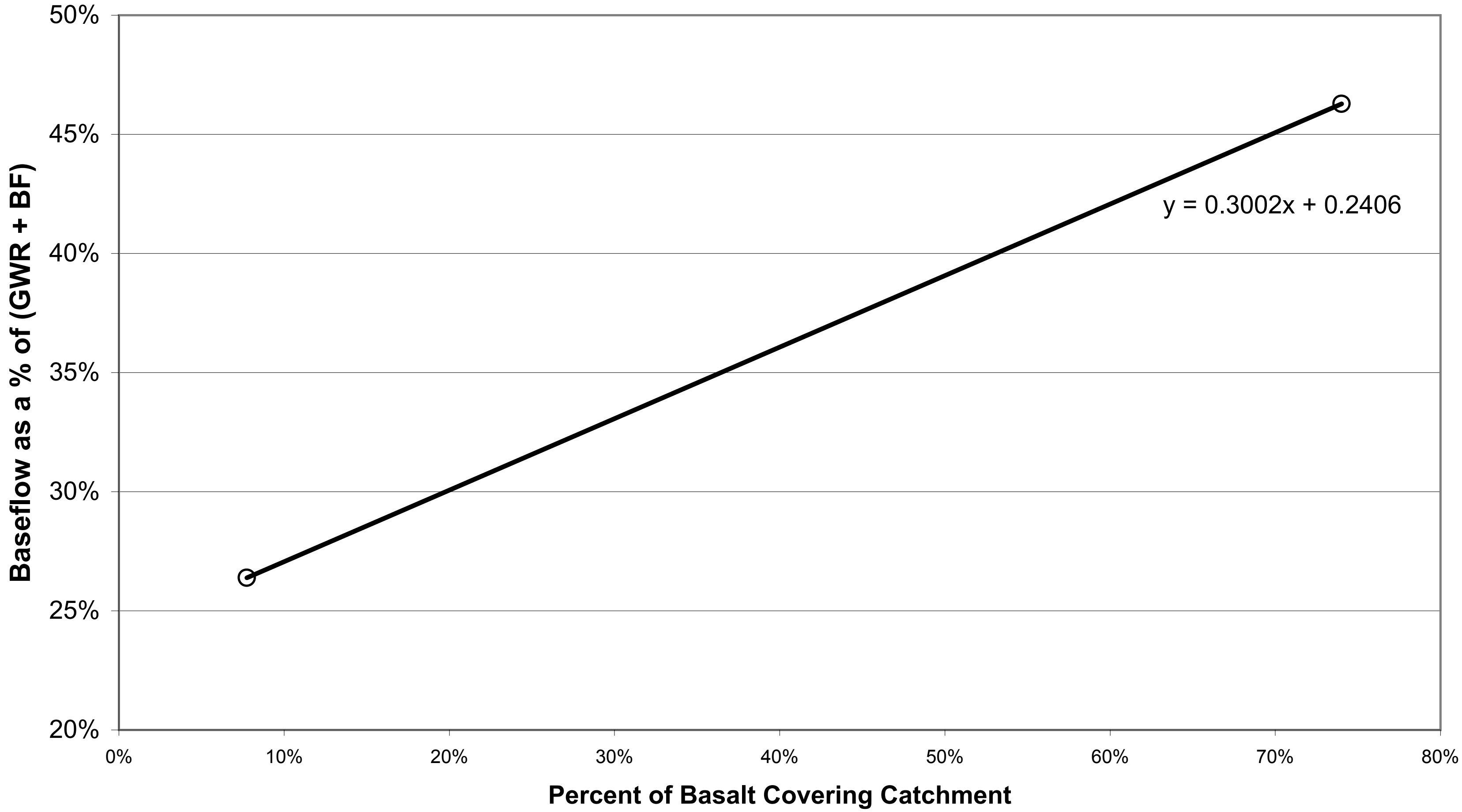

Legend

FIGURE A-4: Annual Baseflow as a Percent of Groundwater Residual + Baseflow

WRIA 14 Planning Unit
Level 1 Assessment

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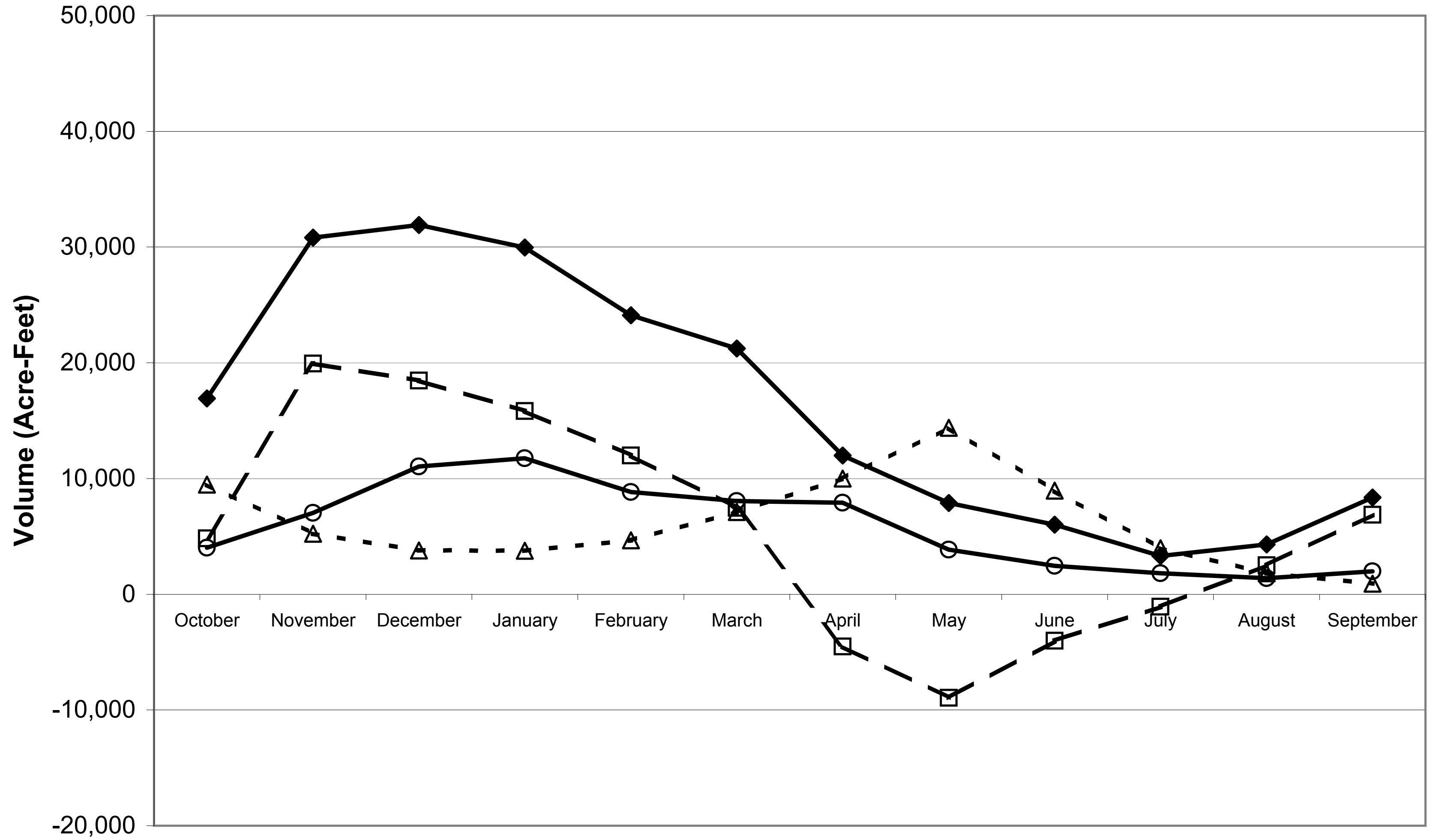
Table A-5
Case Inlet Sub-Basin Water Balance

Month	Precipitation[1]	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
October	16,928	9,465	2,639	4,824	1,390	4,388	-955	4,029	0%
November	30,815	5,242	5,642	19,932	1,390	4,388	14,153	7,032	0%
December	31,901	3,795	9,647	18,460	1,390	4,388	12,681	11,037	0%
January	29,952	3,755	10,356	15,840	1,390	4,388	10,062	11,747	0%
February	24,104	4,669	7,437	11,998	1,390	4,388	6,219	8,827	0%
March	21,244	7,103	6,671	7,470	1,390	4,388	1,691	8,061	0%
April	11,999	9,996	6,512	-4,509	1,390	4,388	-10,288	7,902	0%
May	7,879	14,380	2,460	-8,962	1,390	4,388	-14,740	3,851	0%
June	6,005	8,951	1,062	-4,008	1,390	4,388	-9,786	2,452	0%
July	3,319	3,971	419	-1,072	1,390	4,388	-6,850	1,810	0%
August	4,313	1,805	0	2,508	1,390	4,388	-3,271	1,390	0%
September	8,356	905	588	6,863	1,390	4,388	1,085	1,979	0%
Annual	196,815	74,038	53,433	69,344	16,684	52,660	0	70,117	0%

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Method and a soil moisture holding capacity of 6 inches
3) Runoff calculated as a percent of annual availible water based on the percentage of basalt covering the sub-basin and distributed among the months.
4) Groundwater Residual = Precipitation-Actual Evapotranspiration-Runoff
5) Baseflow is calculated as a percentage of groundwater residual plus baseflow based on the percentage of basalt covering the sub-basin and distributed among the months.
6) Monthly underflow = (annual groundwater residual - baseflow)/12
7) Change in groundwater storage = groundwater residual - baseflow - underflow
8) Streamflow = runoff+ baseflow
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.



Legend

- Precipitation
- Blaney-Criddle Actual Evapotranspiration
- Groundwater Residual
- Streamflow

FIGURE A-5a: Case Inlet - Water Balance

WRIA 14 Planning Unit
Level 1 Assessment

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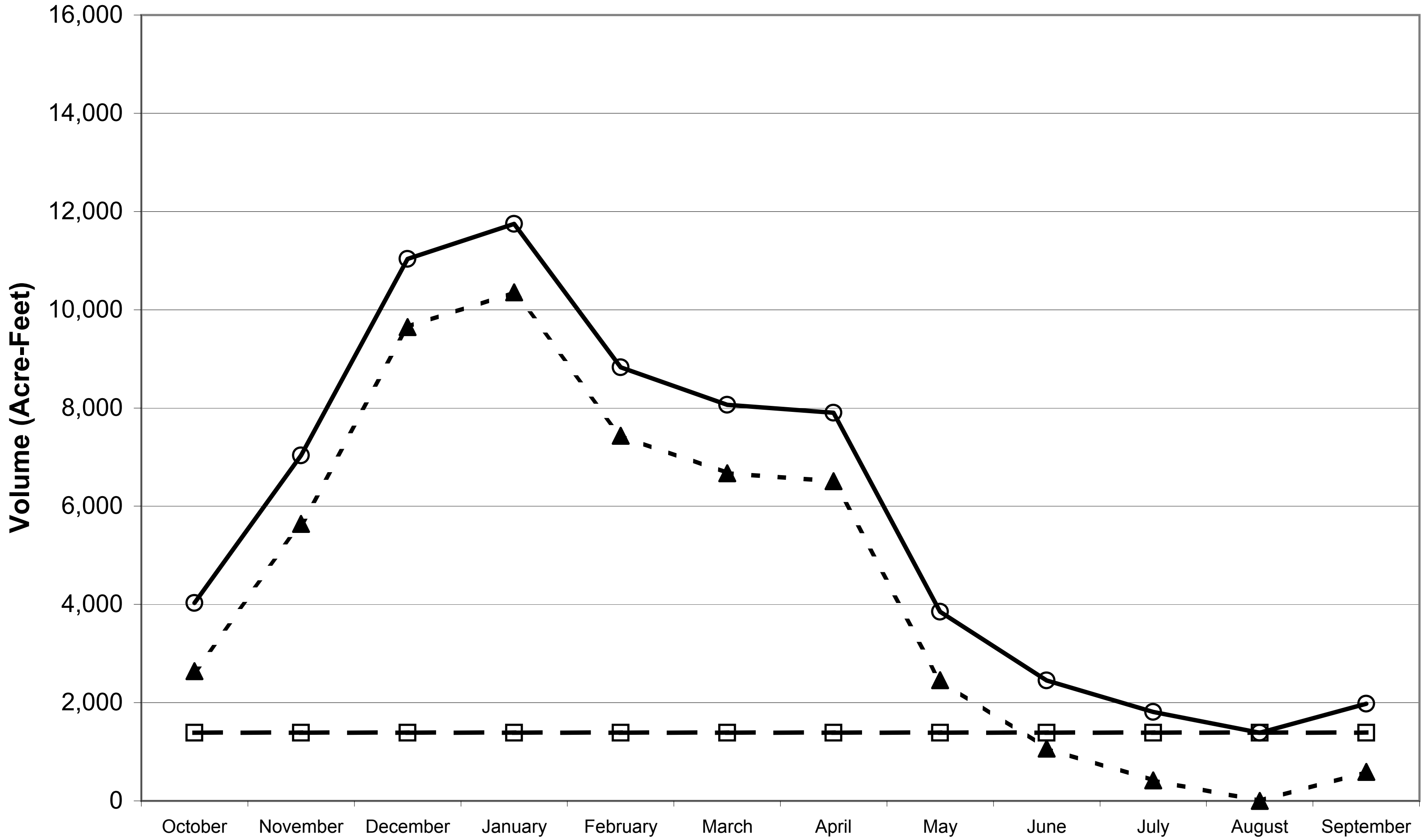

Legend

- Streamflow
- Runoff
- Baseflow

FIGURE A-5b: Case Inlet - Water Balance (Surface Flow)

WRIA 14 Planning Unit
Level 1 Assessment

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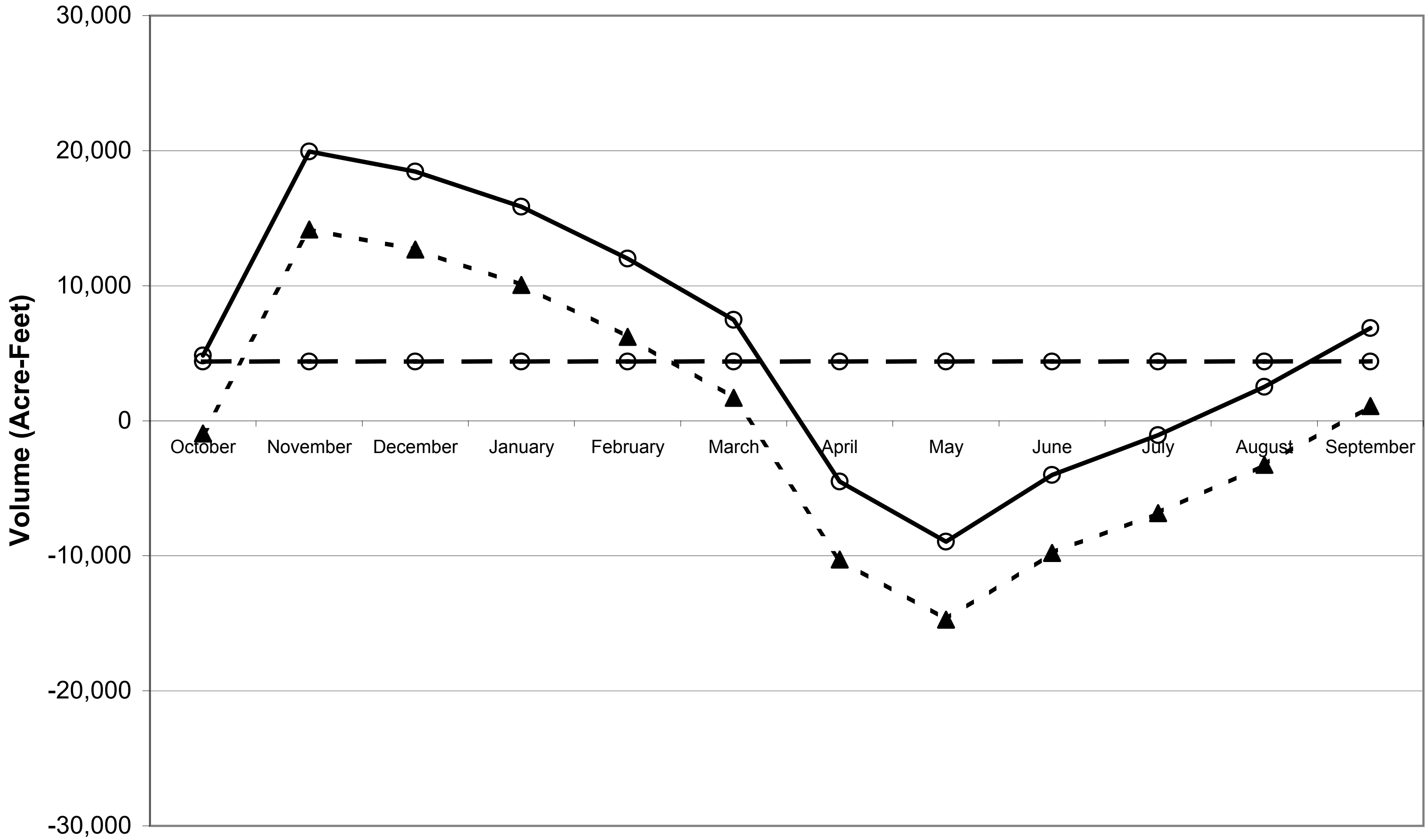

Legend
- Groundwater Residual
- Underflow
- Change in Groundwater Storage

FIGURE A-5c: Case Inlet - Water Balance (Groundwater)

WRIA 14 Planning Unit
Level 1 Assessment

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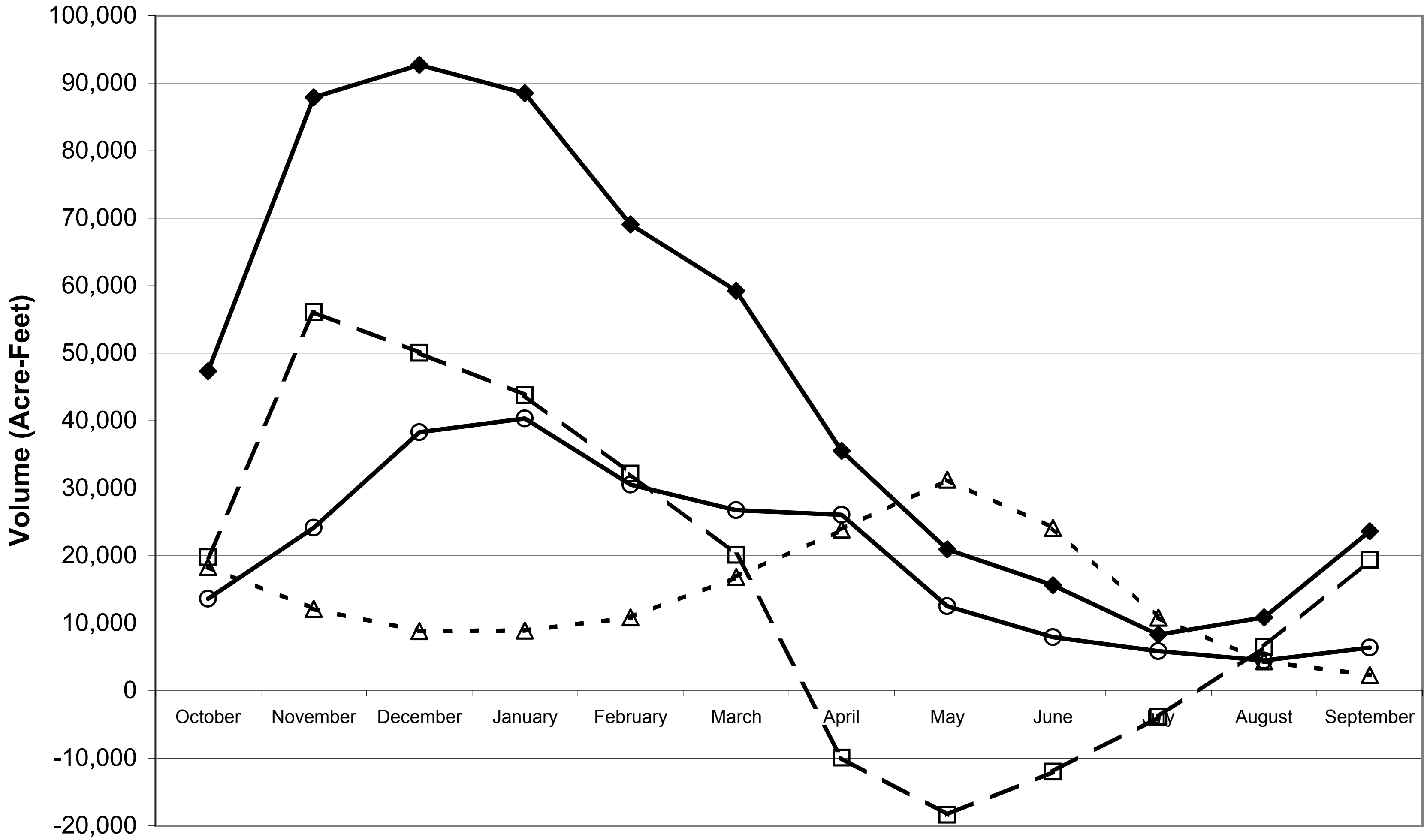
Table A-6
GoldsboroughSub-Basin Water Balance

Month	Precipitation[1]	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
October	47,315	18,321	9,186	19,807	4,413	12,518	2,876	13,599	0%
November	87,901	12,114	19,686	56,102	4,468	12,518	39,116	24,154	0%
December	92,672	8,811	33,811	50,049	4,468	12,518	33,063	38,280	0%
January	88,512	8,889	35,851	43,772	4,468	12,518	26,786	40,319	0%
February	69,049	10,840	26,054	32,156	4,468	12,518	15,170	30,522	0%
March	59,216	16,812	22,281	20,123	4,468	12,518	3,137	26,749	0%
April	35,525	23,846	21,586	-9,907	4,468	12,518	-26,893	26,055	0%
May	20,924	31,247	8,060	-18,383	4,468	12,518	-35,369	12,528	0%
June	15,606	24,123	3,459	-11,976	4,468	12,518	-28,962	7,928	0%
July	8,306	10,795	1,377	-3,866	4,468	12,518	-20,852	5,845	0%
August	10,870	4,349	0	6,522	4,468	12,518	-10,464	4,468	0%
September	23,633	2,326	1,927	19,380	4,468	12,518	2,394	6,395	0%
Annual	559,530	172,474	183,279	203,778	53,563	150,215	0	236,842	0%

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Method and a soil moisture holding capacity of 6 inches
3) Runoff calculated as a percent of annual availible water based on the percentage of basalt covering the sub-basin and distributed among the months.
4) Groundwater Residual = Precipitation-Actual Evapotranspiration-Runoff
5) Baseflow is calculated as a percentage of groundwater residual plus baseflow based on the percentage of basalt covering the sub-basin and distributed among the months.
6) Monthly underflow = (annual groundwater residual - baseflow)/12
7) Change in groundwater storage = groundwater residual - baseflow - underflow
8) Streamflow = runoff+ baseflow
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.



Legend

- Precipitation
- Blaney-Criddle Actual Evapotranspiration
- Groundwater Residual
- Streamflow

FIGURE A-6a: Goldsborough - Water Balance

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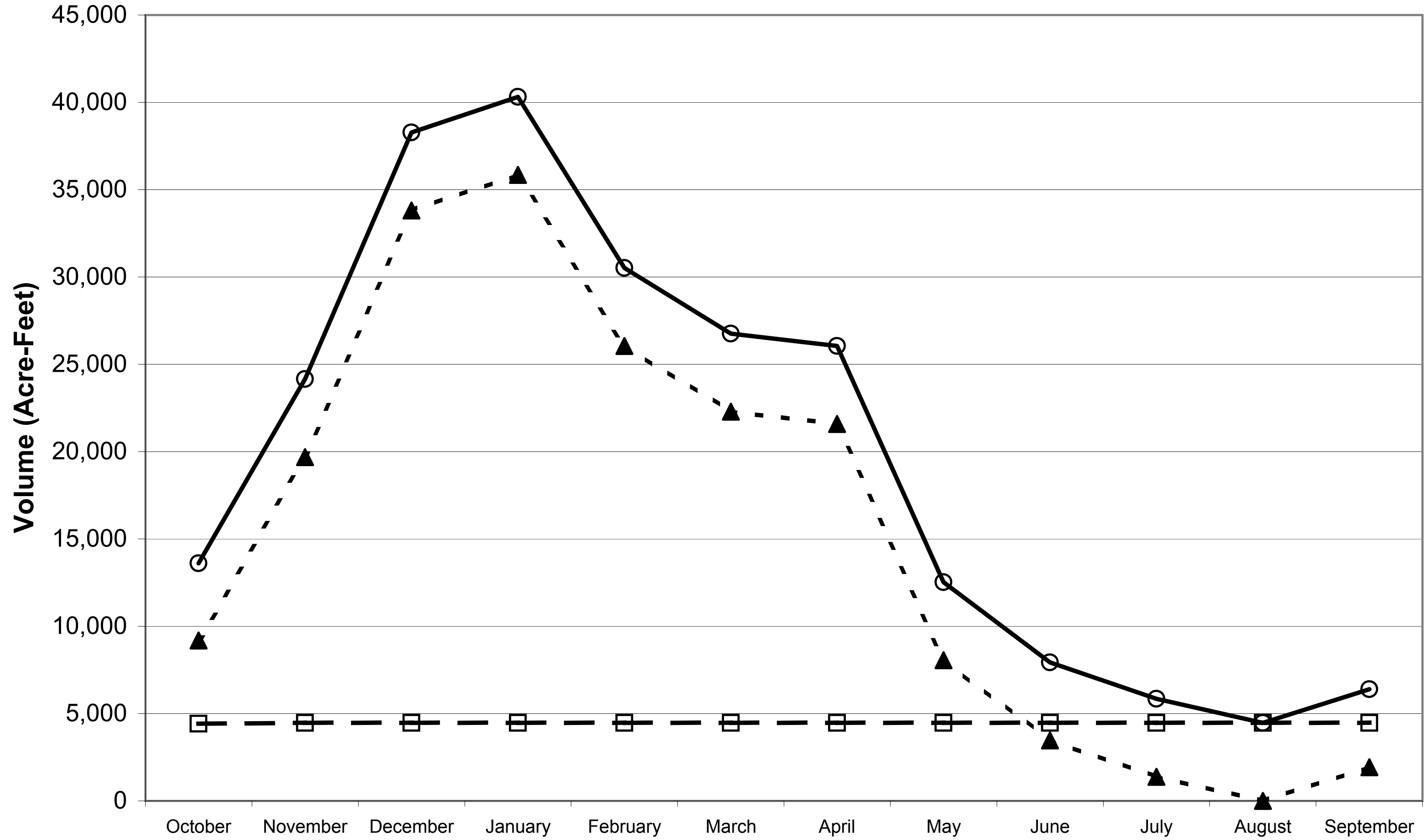

Legend

Streamflow

Runoff

Baseflow

FIGURE A-6b: Goldsborough - Water Balance (Surface Flow)

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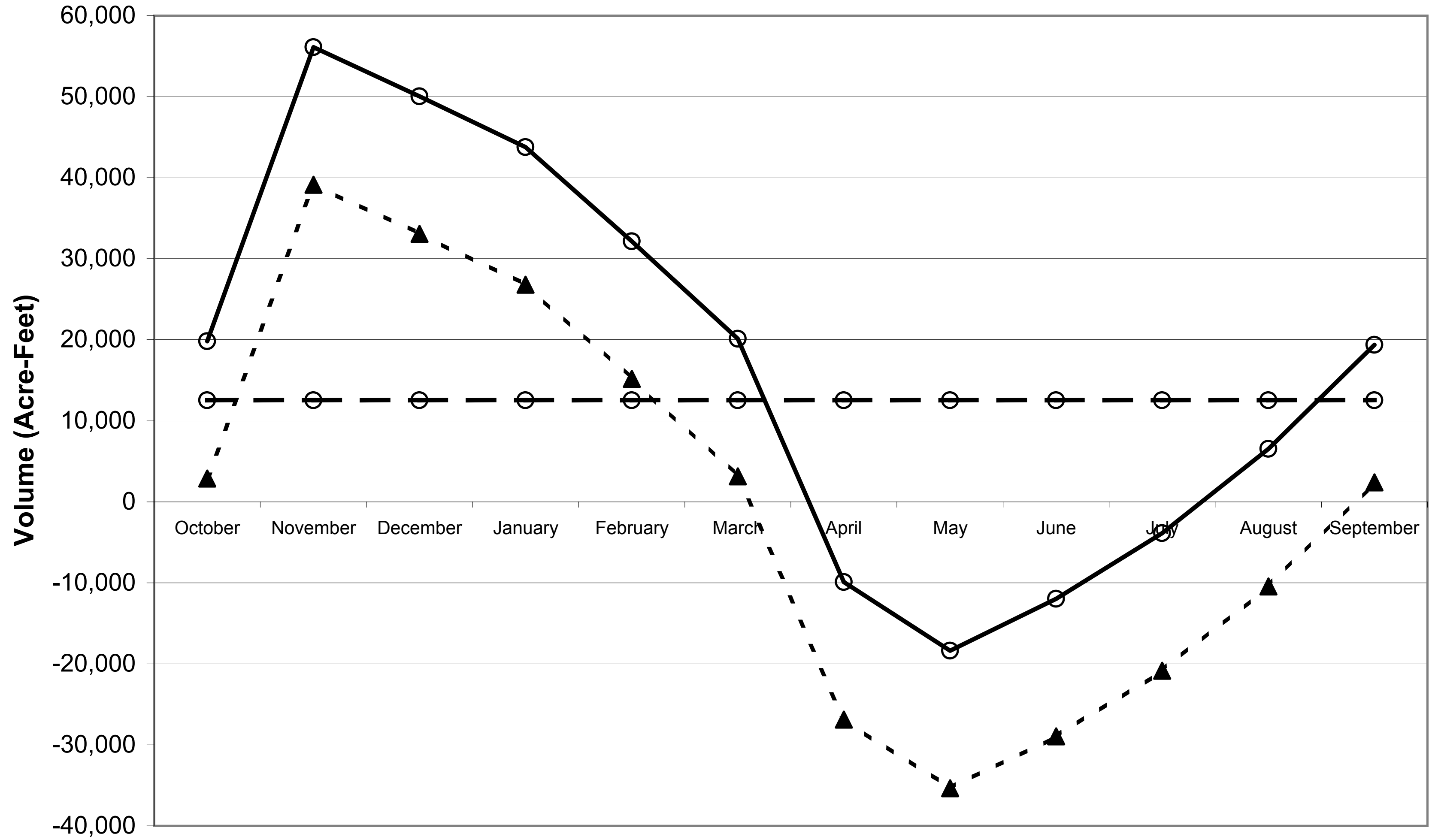

Legend
- Groundwater Residual
- Underflow
- Change in Groundwater Storage

FIGURE A-6c: Goldsborough - Water Balance (Groundwater)

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Table A-7
Kennedy Sub-Basin Water Balance

Month	Precipitation[1]	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
October	15,058	7,529	4,382	3,147	1,197	2,079	-129	5,579	0%
November	27,812	4,049	9,268	14,495	1,197	2,079	11,219	10,466	0%
December	29,475	2,920	16,269	10,286	1,197	2,079	7,010	17,466	0%
January	28,104	2,912	16,216	8,977	1,197	2,079	5,701	17,413	0%
February	21,239	3,685	12,508	5,046	1,197	2,079	1,770	13,705	0%
March	18,499	5,633	8,176	4,690	1,197	2,079	1,413	9,374	0%
April	11,716	7,953	7,525	-3,762	1,197	2,079	-7,038	8,723	0%
May	6,964	10,792	2,577	-6,405	1,197	2,079	-9,682	3,775	0%
June	5,454	8,161	1,059	-3,766	1,197	2,079	-7,043	2,257	0%
July	2,723	3,941	446	-1,665	1,197	2,079	-4,941	1,644	0%
August	3,787	1,704	0	2,083	1,197	2,079	-1,193	1,197	0%
September	7,712	907	614	6,190	1,197	2,079	2,914	1,812	0%
Annual	178,543	60,186	79,041	39,316	14,369	24,947	0	93,410	0%

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Method and a soil moisture holding capacity of 6 inches
3) Runoff calculated as a percent of annual availible water based on the percentage of basalt covering the sub-basin and distributed among the months.
4) Groundwater Residual = Precipitation-Actual Evapotranspiration-Runoff
5) Baseflow is calculated as a percentage of groundwater residual plus baseflow based on the percentage of basalt covering the sub-basin and distributed among the months.
6) Monthly underflow = (annual groundwater residual - baseflow)/12
7) Change in groundwater storage = groundwater residual - baseflow - underflow
8) Streamflow = runoff+ baseflow
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.

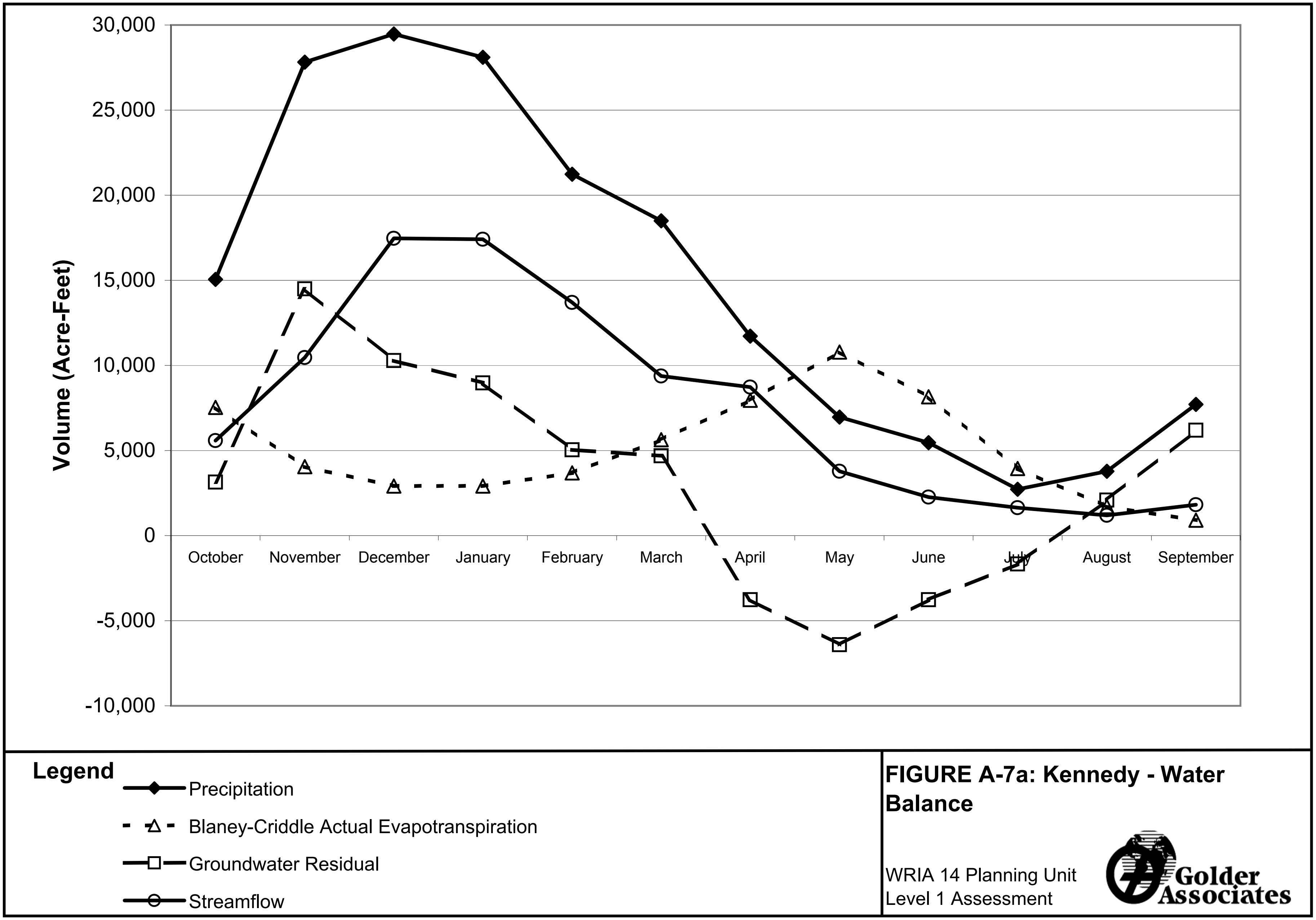

FIGURE A-7a: Kennedy - Water Balance

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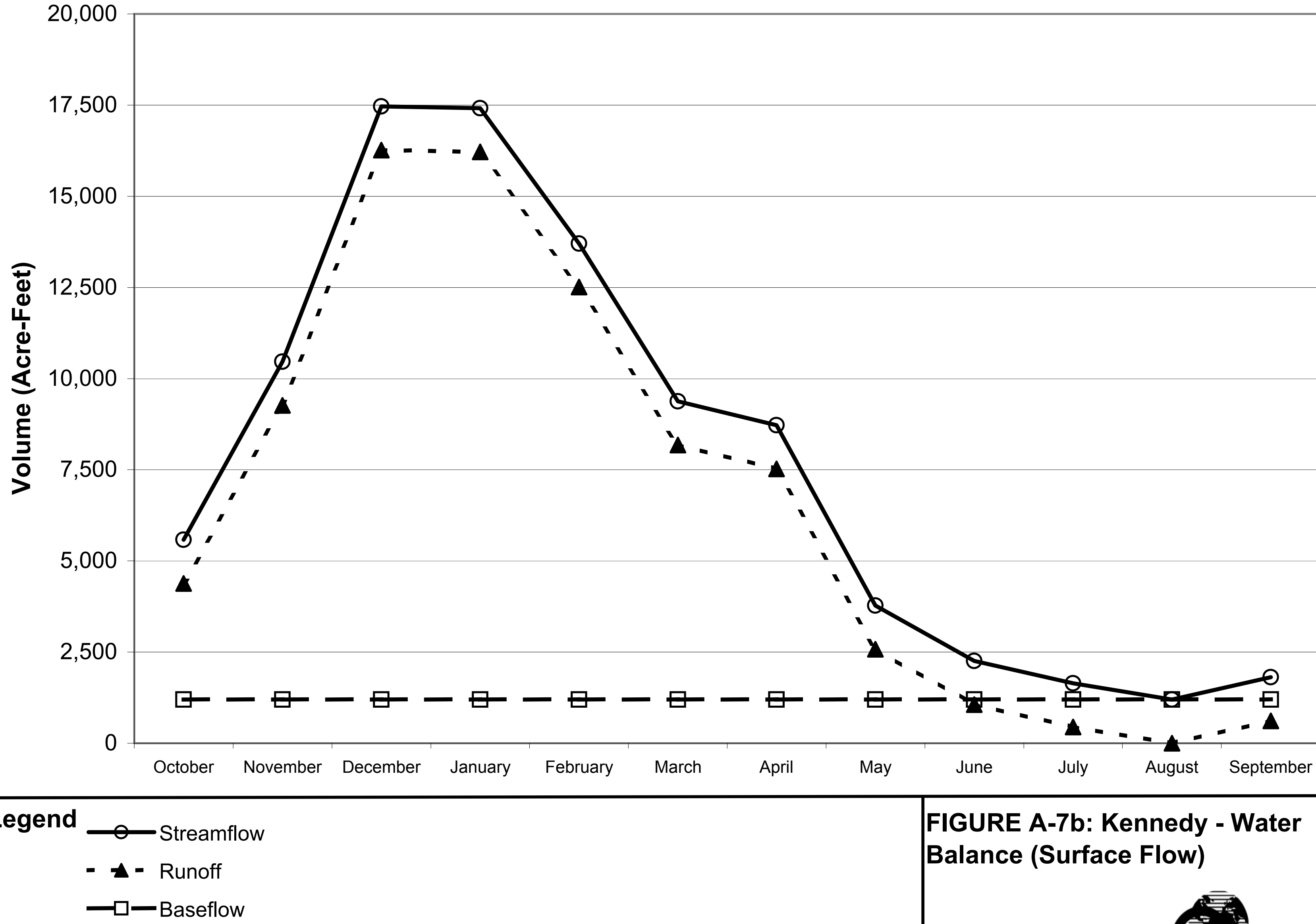

FIGURE A-7b: Kennedy - Water Balance (Surface Flow)

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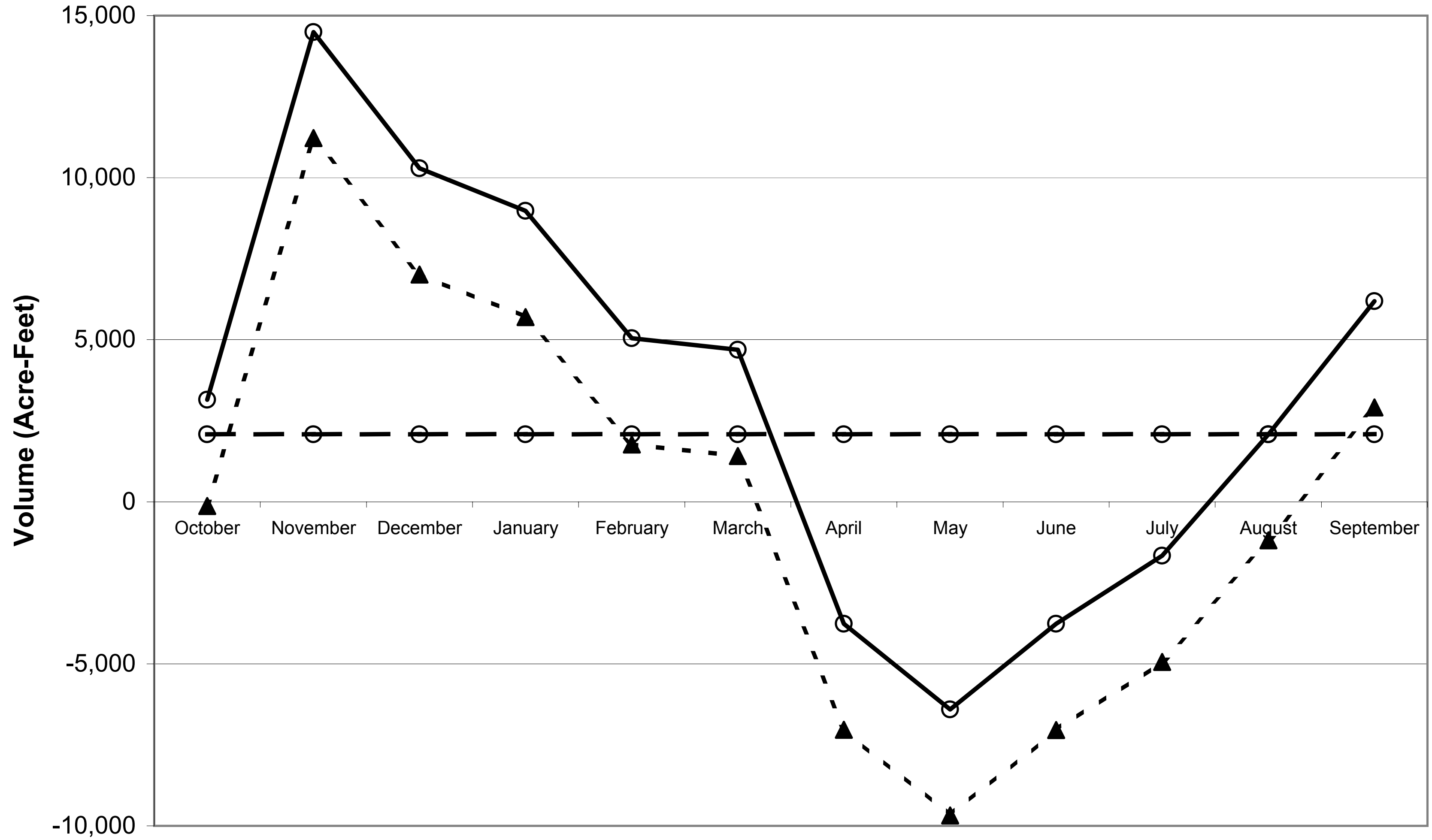

Legend

Groundwater Residual

Underflow

Change in Groundwater Storage

FIGURE A-7c: Kennedy - Water Balance (Groundwater)

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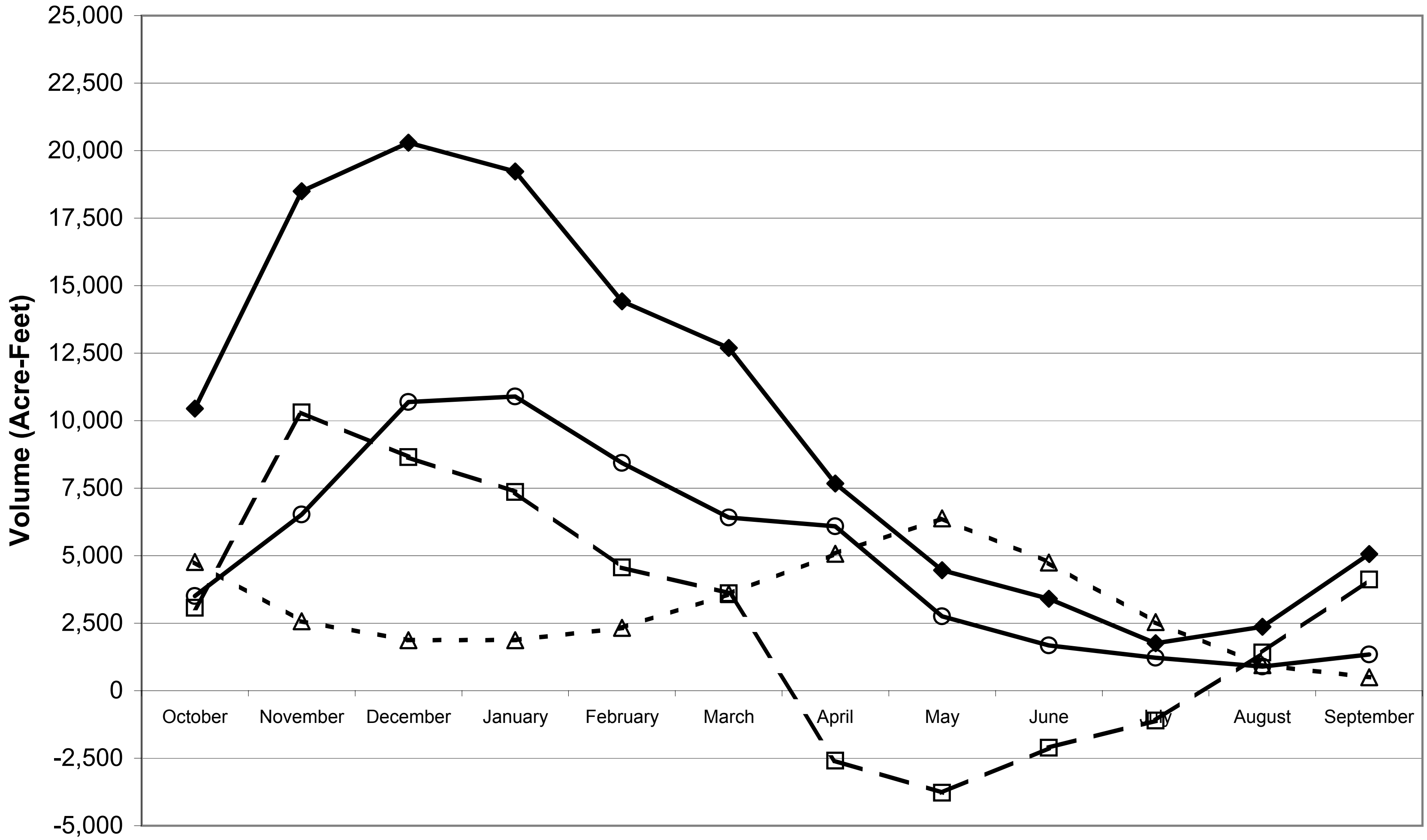
Table A-8
Skookum Sub-Basin Water Balance

Month	Precipitation[1]	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
October	10,446	4,769	2,606	3,071	899	1,893	279	3,504	0%
November	18,500	2,571	5,624	10,305	899	1,893	7,513	6,523	0%
December	20,299	1,866	9,789	8,644	899	1,893	5,853	10,688	0%
January	19,228	1,870	9,997	7,361	899	1,893	4,569	10,896	0%
February	14,421	2,327	7,533	4,562	899	1,893	1,770	8,431	0%
March	12,692	3,573	5,510	3,609	899	1,893	817	6,409	0%
April	7,675	5,070	5,192	-2,588	899	1,893	-5,379	6,091	0%
May	4,459	6,383	1,853	-3,776	899	1,893	-6,568	2,751	0%
June	3,408	4,748	778	-2,117	899	1,893	-4,909	1,677	0%
July	1,755	2,542	319	-1,107	899	1,893	-3,898	1,217	0%
August	2,363	948	0	1,416	899	1,893	-1,376	899	0%
September	5,063	501	442	4,120	899	1,893	1,328	1,341	0%
Annual	120,310	37,167	49,641	33,501	10,785	22,716	0	60,427	0%

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Method and a soil moisture holding capacity of 6 inches
3) Runoff calculated as a percent of annual availible water based on the percentage of basalt covering the sub-basin and distributed among the months.
4) Groundwater Residual = Precipitation-Actual Evapotranspiration-Runoff
5) Baseflow is calculated as a percentage of groundwater residual plus baseflow based on the percentage of basalt covering the sub-basin and distributed among the months.
6) Monthly underflow = (annual groundwater residual - baseflow)/12
7) Change in groundwater storage = groundwater residual - baseflow - underflow
8) Streamflow = runoff+ baseflow
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.



Legend

- Precipitation
- Blaney-Criddle Actual Evapotranspiration
- Groundwater Residual
- Streamflow

FIGURE A-8a: Skookum - Water Balance

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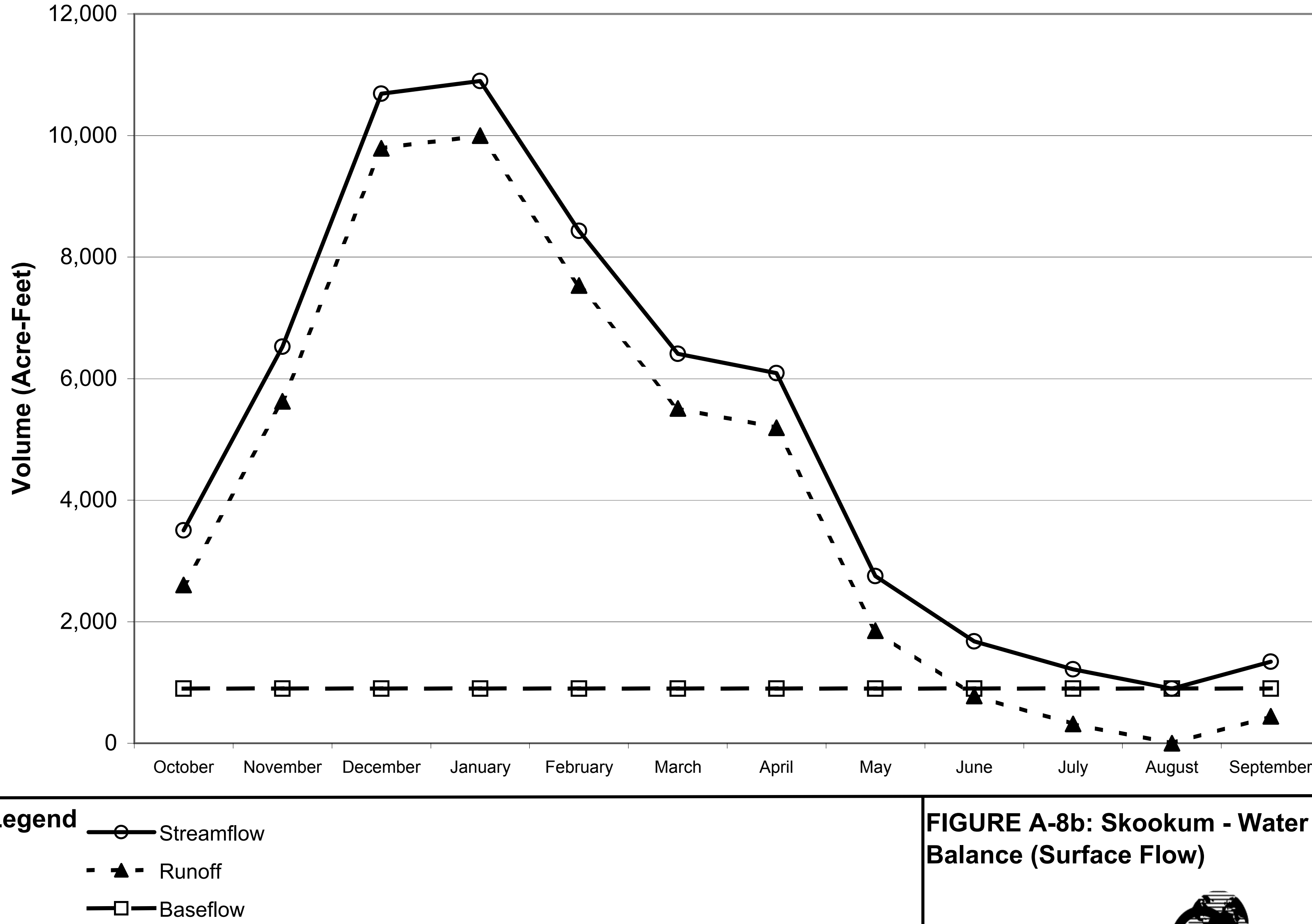

FIGURE A-8b: Skookum - Water Balance (Surface Flow)

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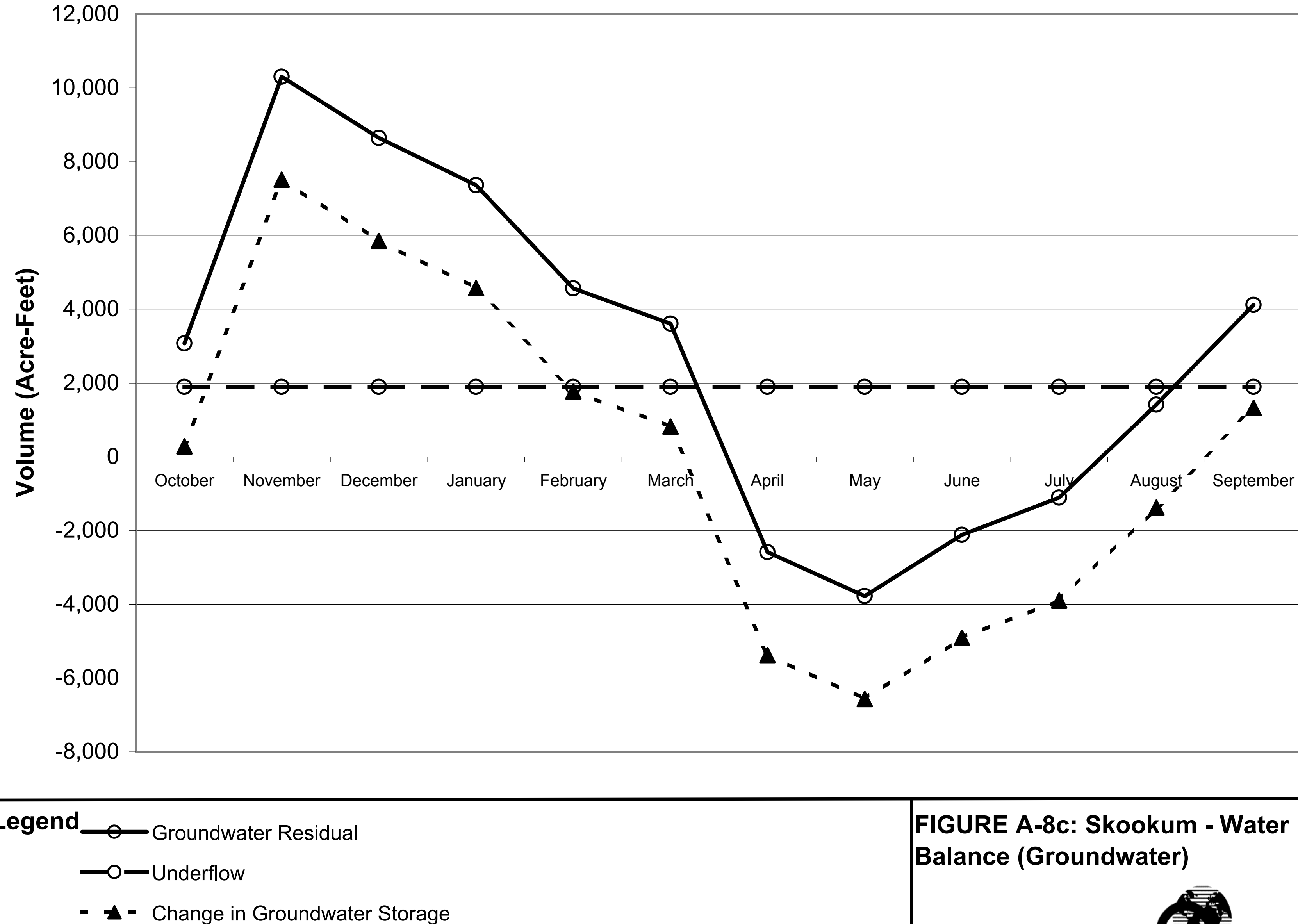

FIGURE A-8c: Skookum - Water Balance (Groundwater)

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Table A-9
Upper Mason Sub-Basin Water Balance

Month	Precipitation[1]	Blaney-Criddle Actual Evapotranspiration[2]	Runoff[3]	Groundwater Residual[4]	Baseflow[5]	Underflow[6]	Change in Groundwater Storage[7]	Streamflow[8]	Balance Residual[9]
October	6,382	3,364	1,037	1,981	546	1,724	-289	1,583	0%
November	11,633	1,824	2,217	7,593	546	1,724	5,322	2,763	0%
December	12,224	1,329	3,791	7,104	546	1,724	4,833	4,337	0%
January	11,461	1,331	4,070	6,061	546	1,724	3,790	4,616	0%
February	9,051	1,631	2,922	4,498	546	1,724	2,227	3,469	0%
March	7,981	2,524	2,621	2,836	546	1,724	565	3,168	0%
April	4,538	3,565	2,559	-1,586	546	1,724	-3,857	3,105	0%
May	2,927	4,710	967	-2,750	546	1,724	-5,021	1,513	0%
June	2,214	3,348	417	-1,551	546	1,724	-3,822	964	0%
July	1,217	1,472	165	-420	546	1,724	-2,691	711	0%
August	1,549	619	0	931	546	1,724	-1,340	546	0%
September	3,111	325	231	2,555	546	1,724	284	778	0%
Annual	74,289	26,043	20,997	27,249	6,556	20,693	0	27,553	0%

Note: 1) Precipitation data obtained from PRISM
2) Actual evapotranspiration calculated using the Blaney-Method and a soil moisture holding capacity of 6 inches

3) Runoff calculated as a percent of annual availible water based on the percentage of basalt covering the sub-basin and distributed among the months.
4) Groundwater Residual = Precipitation-Actual Evapotranspiration-Runoff
5) Baseflow is calculated as a percentage of groundwater residual plus baseflow based on the percentage of basalt covering the sub-basin and distributed among the months.
6) Monthly underflow = (annual groundwater residual - baseflow)/12
7) Change in groundwater storage = groundwater residual - baseflow - underflow
8) Streamflow = runoff+ baseflow
9) Balance residual = precipitation - actual evapotranspiration - runoff - baseflow - underflow - change in groundwater storage
10) All values in acre-feet unless otherwise noted.

APPENDIX B

(Not Provided Electronically)